U.S. Department of the Interior
National Park Service

Cave Cricket Monitoring Protocol for Mammoth Cave National Park, Kentucky

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Important Note: **This sampling protocol consists of this Protocol Narrative and the following Standard Operating Procedures (SOPs):**

SOP 1: Training Sampling Crew
SOP 2: Pre-Sampling
SOP 3a: Field Measures: Plot-based sampling
SOP 3b: Field Measures: Transect-based sampling
SOP 4: Image analysis and image data entry
SOP 5: Post-Sampling
SOP 6: Data Management
SOP 7: Data Analysis
SOP 8: Reporting
SOP 9: Revising the Protocol

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I. Background and Objectives

Rationale for Monitoring Cave Cricket Populations and Issue being Addressed

Cave cricket (hereafter, cricket) population structure and dynamics may be significant to resource managers throughout many of the National Park Service's (NPS) >100 units with cave and karst features. Two cave-dwelling cricket genera (i.e., *Ceuthophilus* spp. and *Hadenoecus* spp.) often inhabit caves throughout the southwestern and southeastern United States (Campbell 1976, Hubbell and Norton 1978, Northup et al. 1992, Hobbs III 1994, Mays 2002, Taylor et al. 2003). These genera are important to cave food webs because they are frequent in time and space, usually dense where they are found, and have a high impact per individual.

Ceuthophilus spp. and *Hadenoecus* spp.are typically the primary conduits for the input of allochthonous organic matter, i.e., eggs and feces, into the terrestrial habitats of caves they inhabit. This allochthonous organic matter supports subsurface communities that may include rare, sometimes endemic, obligate cave-dwelling invertebrates (Culver et al. 2000). For example, in southeastern Texas the endangered Tooth Cave ground beetle (*Rhadine persephone*) feeds largely on the eggs and nymphs of a cave cricket (*Ceuthophilus secretus*). In Mammoth Cave National Park (MACA), *Hadenoecus subterraneus* subsidizes three distinct subsurface communities with its eggs and feces (Poulson and Lavoie 2000). The effects of natural variation (e.g., drought), exotic species (e.g., Red Imported Fire Ants (*Solenopsis invicta*)) and management decisions on surface and subsurface habitat (e.g., altered cave entrance configuration) on cricket population structure and dynamics have the potential to affect the flow of allochthonous organic matter into caves (Poulson et al. 1995).

One of MACA's top management questions regarding crickets, i.e., do cave entrance modifications impact cricket populations, indicates the need to monitor the status and trends of cricket populations in developed and undeveloped caves at MACA. This is because anthropogenic and natural stressors can cause fluctuations in cricket populations over time and so initiate a trophic cascade throughout a cave's terrestrial food web. For example, variable climatic conditions over a thirty year period affected the favorability of surface foraging conditions for crickets and so caused fluctuations in the amount of cricket guano available to the guano community; fluctuations in these subsidies in turn affected guano community population dynamics (Poulson et al. 1995).

Resource managers at NPS cave and karst units with significant cave cricket populations may want to implement long-term protocols to monitor cricket populations. Long term monitoring of cricket population structure and dynamics will elucidate the effects of management actions on cave cricket populations and provide resource managers with an index of overall robustness of cave terrestrial invertebrate communities. Here we propose a method that will provide a long-term index of cricket population structure and dynamics through time and space. This method was developed for caves at MACA but is readily adapted to other NPS cave and karst units.

Historical Development of Cave Invertebrate Monitoring

Previous attempts by researchers to quantify populations of terrestrial cave invertebrates were inadequate for the purposes of a long-term ecological monitoring program in that they lacked a focal indicator species or used labor intensive methods to gather data (Nicholas and Brucker 1965, Mitchell 1970b, a, Tercafs and Brouwir 1991,

Bernardini et al. 1996, Di Russo et al. 1999, Poulson et al. 2000, Mays 2002). One of the primary goals of long term ecological monitoring programs is to maximize the amount of information gained as a function of time spent in the field. Thus, cost-effective monitoring methods should focus on indicator species that provide resource managers with an index of overall robustness of communities in question.

Some efforts at monitoring cave arthropods were diffuse in that researchers attempted to monitor many species at once (Mitchell 1970b, a, Di Russo et al. 1999, Mays 2002). For example, rather than monitor one key indicator species, Mays (2002) attempted to quantify population sizes and spatial distributions of nine cave invertebrate species in Great Smoky Mountains National Park. While Mays' (2002) quantitative methods were efficacious, a monthly monitoring program for nine cave invertebrate species would be impractical among more than a few caves. Indeed, Mays' (2002) data were collected at only one cave, Gregorys Cave, at Great Smoky Mountains National Park. While Poulson et al. (2000) censused a single key species (i.e., *H. subterraneus*) at nine caves in MACA, their method was highly labor intensive in that it involved a total census, i.e., counting every visible cricket within tens of meters of cave passage.

To be efficacious, a monitoring method developed for the National Park Service must be cost effective and meet the needs of park management. Thus, MACA division chiefs were solicited for comments on which objectives of the cave cricket monitoring protocol they would find most useful for their purposes (and ultimately, MACA's purposes). The following objectives were finalized subsequent to receipt and incorporation of the commentary supplied by MACA's division chiefs.

Measurable Objectives

There are two primary objectives for the monitoring described in this protocol:

1. Determine temporal changes in population structure (e.g., age class and sex ratio) and relative abundance of cave crickets in sets of developed and undeveloped caves across MACA.
2. Determine potential effects of active management decisions, e.g., alteration of cave entrances, on cave cricket ecology within actively managed caves. Specific study focus will include assessment of cave-entrance modification effects on cricket exit/entry patterns, management impact on population structure, and localized impacts on cricket use of ceiling roosts.

II. Sampling Design

Rationale for Selecting this Sampling Design over Others

Unlike sampling approaches for monitoring surface taxa there are few, if any, sampling approaches that account for the inherent constraints involved when sampling subsurface taxa among many caves. For instance, cave entrances can be widely distributed across managed landscapes like MACA and so can present logistical problems with available time and staff. Time and staff constraints imposed by widely distributed cave entrances can strongly limit how many caves can be monitored. In addition, the number of developed caves in a national park will also limit the number of available comparisons between developed and undeveloped caves and so limit the data's applied value to park management. Every cave also presents a unique sampling space with

differing safety issues, accessibility to samplers, inherent structural complexity, size, and cave cricket populations.

Sampling cave cricket populations is complicated because the ceilings on which they roost can exhibit high relief and so density and area estimators are likely unreliable. High ceiling relief can also affect probability of detection among cave cricket stages and so lead to high error rates in larger scale sampling. Finally, violations of conventional assumptions for sampling populations due to the above factors, among others, lead to our *de novo* development of a sampling design.

The sampling design described in this protocol involves two parallel, simultaneously implemented sampling methodologies to collect 2 sets of data within each cave. Both methodologies involve the passive collection of data and so cave crickets are not handled in any way. The methodologies are executed in two sampling region located proximally and distally with respect to the human accessible entrance of each sample cave. In each sampling region, a fixed landmark will serve as an anchor point that orients the two sampling methodologies.

One method, dynamic plot clusters, involves eight unfixed, objectively located plots keyed on dense patches of aggregated crickets. Data on cave crickets in the dynamic plots is collected with digital photographs. The advantage to collecting data with digital photographs is that they can be archived and retrieved in future. Thus, data mining is possible as long as the medium on which the data are recorded (e.g., compact discs) lasts. Further, objectively locating these plots greatly reduces the chances of collecting null data points.

The other method, fixed linear transect arrays, are five sets of paired, parallel linear transects established across the cave ceiling within each sampling region. The ten transects are delineated by laser chalk lines projected on the cave ceiling. Thus, the cave is not marred in any way during the execution of both data collection methods.

Site Selection

Because time and money are finite resources among all NPS units, resource managers will most likely have to monitor a representative sample of caves from their available pool of caves. Thus, each monitoring cave must be carefully chosen to maximize the amount of information gained as a function of time spent in the field. The following process to select monitoring caves is useful to consider regardless of whether or not the NPS unit in question is densely populated with caves.

Pre-field vetting: Data mining

This section assumes the NPS unit possesses an extant, searchable computer database with information on the caves within its boundaries. If the data are contained in paper files, the process is obviously slowed somewhat but the search criteria still largely apply. The following criteria may be considered more or less a sequential winnowing process to produce a short list of potential monitoring caves prior to field vetting.

1. If the cave database is searchable, an initial keyword search for files that contain the word “cave crickets” should greatly reduce the number of files that must be examined closely (Appendix A). Examine the resultant files for any description of relative abundance of cave crickets and use this as part of your decision matrix as to whether or not a particular cave should be included in monitoring.

2. Examine the file's notes regarding ease of access to the cave. If getting to the cave is particularly arduous or dangerous, it should be included only if there is no alternative. Further, if the cave's morphology is such that access can only be obtained by field assistants with technical skills (e.g., rope climbing) or tight spots that would complicate rescue it should be considered with reluctance.
3. Consult park maps to determine cave location with respect to the starting point of monitoring teams (i.e., offices). Location of the cave with respect to offices is an important criterion to consider beforehand because it will determine driving and/or walking distance. Travel time to and from the caves will likely have the largest effect on the amount of time monitoring crews spend in the field. GPS coordinates, if available from the file, should be downloaded or programmed into a GPS unit to facilitate finding the cave.

Field vetting potential monitoring caves

While this section assumes some information was gained from data mining, many of the same criteria used in the pre-vetting process are mentioned below. Often field notes on file can be vague and so clearly there is some value to confirming, in the field, the information gained during the data mining process. Field vetting is particularly useful if the notes from the database suggest a cave is marginally promising. The following criteria may be considered more or less a sequential winnowing process to produce a short list of potential monitoring caves to include in the scoring process. Standardized data sheets should be created for the field vetting process (Appendix B).

1. Trip times from base, including drive time/walking time, should be carefully recorded in a field notebook. Walking time may be an especially important criterion due to its potential to significantly increase time in the field. Potential monitoring caves can and should be considered with reluctance, and scored accordingly, if walking time is too great. Obviously, determining what constitutes a long walk is subjective; the rule of thumb used at MACA was a walk >15 min could, all things being equal, result in rejection of a potential monitoring cave.
2. Ease of access and safety hazards should be carefully noted and recorded in a field notebook. Safety is an especially important criterion and any safety concerns about a potential monitoring cave should result in its rejection from the list if safer alternatives exist.
3. Cave morphology such as ceiling height and relief should be carefully noted and measured where possible. Ceiling height and relief should be examined in field vetting because high and/or complex ceilings can significantly reduce accuracy and precision of monitoring data. Ceiling height is an important criterion to consider for ease of discerning numbers of crickets, sex, and instar or size class. Low ceiling relief is an important criterion because crickets may hide in pockets of complex cave ceilings. Areas of high and/or low ceiling relief should be noted on the cave data sheet and could also be indicated on a map of the cave.
4. The relative abundance of cave crickets in a potential monitoring cave is a significant criterion to note in the field vetting process. Notes on relative abundance of clusters and ratios of juvenile to adult crickets should be recorded on data sheets and cave maps. Cave maps are a useful part of field equipment in this part of the field vetting process. Cave maps can be marked, in pencil, where

clusters of cave crickets and their guano deposits were found. Guano deposits are particularly informative in determining where cave crickets regularly roost because roosts must be used over time to build guano deposits whereas clusters of cave crickets can be transient as they cycle to and from the cave entrance. A semi-quantitative method should be used to indicate relative abundance of cricket clusters on the map, e.g., circles of increasing size and numerical value, to facilitate scoring among caves for in the Monitoring Cave Rating Process.

Monitoring Cave Rating Process:

This section assumes the field vetting process yielded a number of prospective monitoring caves. Prospective monitoring caves should be ranked from best to worst according to the four criteria evaluated in the field vetting process (Appendix C). The ranking process involves assigning each criterion a weighted numerical value and using the sums of these four values to rank the caves. The weights and importance assigned to each criterion in the rating process reflects their importance in obtaining adequate data during the sampling process. Not surprisingly, the semi-quantitative data on cave cricket abundance/population structure and cave ceiling height/relief obtained during the vetting process is weighted more heavily in the rating process than trip time and ease of access (Appendix C); this is because the farthest, most difficult to access caves were eliminated during the field vetting process. The cave with the highest summed value is ranked the best prospective monitoring cave and the rankings decrease sequentially to the worst ranked cave. The list generated in the rating process provides the user with defensible reasons why lower ranked caves may be excluded from a proposed sampling plan.

Populations Being Monitored

Our primary goal is to field test this protocol for one year on sample populations of cave crickets (*Hadenoecus subterraneus*) among twelve caves, i.e., six developed and six undeveloped, in Mammoth Cave National Park (Appendix D). Incidental data on other cave inhabiting orthoptera, i.e., *Ceuthophilus* spp., may be collected because the two can occur simultaneously.

Sampling Frequency and Replication

During the test phase, monitoring will occur once per month but given that survey trips are rather brief, ca. one hour per cave, the number of trips could increase if necessary. Personnel schedules will be worked out as much in advance as possible to ensure appropriate sampling frequency and intensity during the test phase. An appropriate sampling frequency and intensity will be recommended following completion of this pilot project to assess the within and between year variability in cricket occurrence and abundance. Once preliminary estimates of variability are available, we will examine the level of detectable change for a given sampling intensity; sampling intensity may then be adjusted accordingly.

III. Field Methods

Field Season Preparations, Field Schedule and Equipment Setup

If long intervals among sampling trips occur then observers should review this entire protocol, including the SOPs, prior to that period's sampling trips. Observers

should thoroughly review SOP #1 "Training Observers" and SOP #2 "Pre-Sampling". All equipment should be checked and readied for field season. All electronic equipment (i.e., laser levels, digital cameras, headlamps, should be checked to make sure it is in working order, battery charges in all battery-operated equipment should be verified and exhausted batteries replaced. Logistical and equipment checklists are provided in SOP #2 "Pre-Sampling". Finally, observers should review photographs of cave crickets species to reduce the incidence of misidentification in the field.

While weather conditions should not significantly affect accessibility to field sites scheduling fieldwork could be affected by staff workloads. Further, project managers may want to schedule trips opportunistically to take advantage of cave crickets' significant numerical response to rainfall. Thus, sampling trip dates should be determined well in advance to maintain schedule flexibility. To accommodate staff workloads, sampling trips will be scheduled over multiple days but within as close a time span as possible; thus, the effect of weather and cricket movement within caves on among cave sample variance should be minimized.

Sampling Methods

Two simultaneous sampling methods are executed in this protocol: dynamic plot clusters (SOP #3a "Field Measures: Plot-based sampling") and fixed transects (SOP #3b "Field Measures: Transect-based sampling"). Two crews (3-4 personnel per crew) each survey one cave pair, i.e., one developed cave and one undeveloped cave, per day. Caves are surveyed in the morning because cave crickets forage during the evening; this will ensure a mix of incoming and outgoing crickets will be scattered throughout the passage. Data are first gathered proximal to the entrance and data distal to the entrance are gathered last. While two crew members set up the equipment at the proximal station the remaining crew member should walk throughout the cave to scout locations of cricket clusters. The locations should be noted and pointed out to the photographer. Because cave crickets are sensitive to disturbance caves with active tours should be sampled well before the tour schedule begins so as not to affect sampling results.

Before leaving each cave, all data books and electronic forms should be checked for completeness. All data should be entered into database programs on the day they are recorded. The project manager is responsible for the safekeeping and organization of data sheets and ensuring that data are entered into the database.

Conducting the Sampling

Dynamic plot clusters and fixed linear transects, which form the centerpiece of this protocol, are explained in detail in SOPs #3a and 3b but are summarized here. Each field team examines a pair of caves, one developed and one undeveloped, in the course of one field day. Data are recorded in two sampling regions, one distal and one proximal, to the entrance of each cave. Each sampling region contains a fixed landmark that serves as a reference point from which all data are collected. While the equipment is being set up at the landmark one team members scouts and, if possible, notes eight locations of densely aggregated crickets on the cave ceiling. When the tripod is centered on the landmark and the laser platform affixed the center laser is activated and pointed to the first plot. Using the laser beam as a reference, a compass reading on the plot is recorded. The distance from the landmark to the plot is also measured using a tape measure.

Crickets in the plot are then photographed with a digital camera mounted on a monopod. This process is repeated seven more times for a total of eight dynamic plots per region.

Data on individual crickets in the dynamic plots are assembled from an examination of the digital images on a PC back at the office. These "raw" data are then converted into pooled variables for analysis. These pooled variables include total counts of all individual crickets and counts of individuals classified by stage, sex, feeding state, and numbers of appendages lost.

Starting from the landmark a tape is used to bisect the sampling region by orienting it parallel with the run of the cave passage. The laser platform, with all three parallel laser beams perpendicular to the tape, is placed at two meter increments with the middle laser centered on each two meter increment. The beams are then projected on the ceiling to form two parallel transects. Data consist of simple counts of all crickets in transects and are recorded on a virtual form or in a notebook. Five paired transects are collected in this manner for a total of ten transects per region. Finally, temperature and relative humidity data near cave entrances will be collected continuously by HOBO data loggers and within the sampling areas using a Thermohygrometer.

IV. Data Management

Overview of Database Design

Following the lead of the National Park Service (NPS) and the Inventory and Monitoring (I&M) Program, CUPN-MACA Monitoring Program has adopted MS Access XP (2002) as its desktop database standard and ArcGIS as the GIS standard.

Rather than developing a single, integrated database system, CUPN-MACA relies upon modular, standalone project databases that share design standards based on the I&M Program's Natural Resource Database Template (NRDT) with links to shared lookup tables housed in a centralized database. This and other protocol databases developed by CUPN-MACA share certain design standards. This is important given the often unpredictable ways in which datasets may be aggregated and summarized. Each protocol database is developed using the following primary components:

It should be noted the current database model for this protocol was developed using the NRDT, phase II tables and structure, where possible. However, recent (December 2004) proposed changes (phase III) to the NRDT will likely result in significant changes to the data model presented in SOP #6, as the sampling methodology and data model are further developed.

1. *Common lookup tables* – Links to entire tables that reside in a centralized database, rather than storing redundant information in each database. These tables contain information that is not project-specific (e.g., lists of parks, personnel, and species).
2. *Core tables and fields based on CUPN-MACA and national templates* – These tables and fields are used to manage the information describing the "who, where and when" of project data. Core tables are distinguished from common lookup tables in that they reside in each individual project database and are populated locally. These core tables contain critical data fields that are standardized with regard to data types, field names, and domain ranges.

3. *Project-specific tables and fields* – The remainder of database objects can be considered project-specific, although there will typically be a large amount of overlap among projects. For example, a time field will require similar data types and domain values.

A noteworthy deviation from the NRDT for this and other cave-related protocols is the development of a "tlu_Cave_Locations" table. It is a common lookup table shared by all cave protocols. While this table contains the exact structure and fields found in the NRDT, phase II table "tblLocations", it also contains additional cave-specific fields. The decision to break out cave location information in this manner was made in large measure due to its recognized sensitivity level. The project-specific data tables for this protocol include:

- tblLandmark – Contains a description and directions to each landmark utilized as a sampling reference point.
- tblPlotObservation – Contains plot location and observer metadata, as well as plot level observational data.
- tblTransectObservation – Contains observational information for each transect.
- tblCricketObservation – Contains observational information for each cricket identified within the plot photographs.

Data Entry

Extensive use of programmatic data validation has been incorporated to greatly reduce the number of operator entry errors. Rather than direct database table entry, customized forms are being designed and tested that provide a natural flow of data entry into the database and validate the entered data before allowing them to be written to the database. Where possible, data are entered via the use of dropdown lists (i.e., built into the form or separate lookup tables) or by typing the beginning characters of the value, thus eliminating a large proportion of potential operator entry errors.

For other data fields, validation controls prevent impossible values to be entered (e.g., a negative number of crickets found in a transect) and data entry alert messages are provided any time a datum is entered that is not realistic (e.g., a plot temperature of 95 C). The user is offered a chance to reenter the data or keep the abnormal data. If the user accepts the abnormal data, a log file will be generated listing pertinent information about the out-of-range data (e.g., sample number, fields, entry operator, sample collector, etc.). The log file is submitted to the project leader.

Data Verification and Editing

In addition to data verification accomplished by the computer program, the data will also be manually verified shortly after data entry. This process involves checking the

accuracy of computerized records against the original source. To minimize transcription errors, our policy is to verify 10 percent of the records to their original source by staff familiar with project design and field implementation.

The primary goal of data entry verification is to determine where errors are being introduced into the database. Each error found will, of course, be corrected, but will additionally be cataloged to find methods for eliminating that specific type of error during subsequent collection periods.

Metadata Procedures

While the importance of metadata is universally accepted within the data management community, the approaches for collection and levels of detail are varied (sometimes referred to as the "101 ways"). A primary component of our dataset documentation approach is the I&M Program's Dataset Catalog. Dataset Catalog provides a means whereby CUPN-MACA can organize, maintain, and disseminate brief metadata on its dataset holdings. In addition, staff can identify and prioritize datasets for which formal metadata will be developed and identify the status of metadata documentation for a particular dataset (i.e., planned, in work, or complete).

A Dataset Catalog record will be entered by the data manager, based on information provided by the project leader. It is the shared responsibility of the data manager and project leader to ensure this record is accurate and remains up-to-date. The decision to develop Federal Geographic Data Committee (FGDC) compliant metadata, utilizing the FGDC Biological Data Profile, for the tabular dataset produced by this protocol will be based upon (1) its level of use in analysis, (2) the amount of requests received for data sharing, (3) and staff workloads. All GIS layers generated from this project will be documented with applicable FGDC and NPS metadata standards.

Data Archival Procedures

This and other monitoring protocols will have variable long-term data archiving requirements. Modifications to protocols will typically require complete datasets to be archived before modifications are implemented. Archived datasets or subsets destined for long-term archiving will be saved in their native formats. To ensure the capability of accessing the data the application software will be maintained. If it is not possible to archive or support the application software, the data will be stored in ASCII text files.

Versioning of archived datasets is handled by adding a three digit number to the file name, with the first version being numbered 001. Each subsequent version is assigned a sequentially higher number.

Tabular datasets destined for archiving will be stored locally within an object-oriented file structure established on the MACA file server. Currently this server is backed up to an HP Superstore Autoloader nine tape carousel using DLT tapes. All backups are

performed and monitored by MACA IT system administrators. Currently GIS files are maintained and archived separately by the GIS specialists.

V. Analysis and Reporting

Reporting falls into two separate categories while analyses will answer similar questions on different time scales. Annual status reports will examine within-year patterns in cricket population structure and dynamics among managed and unmanaged caves using descriptive statistics, graphic analysis, and correlative statistics. Summary reports will also address patterns in cricket population structure and dynamics among managed and unmanaged caves, using similar statistical analyses, but will do so with cumulative data on a scale spanning multiple years. Refer to SOP #7 "Data Analysis" and #8 "Reporting" for details.

VI. Personnel Requirements and Training

Roles and responsibilities

The overall project leader is the lead ecologist for implementing this monitoring protocol and is supervised by the Program Coordinator for the Mammoth Cave Prototype Long Term Ecological Monitoring Program. Because experience with cave crickets and photography are necessary requisites for the successful collection of archival data, the project leader and another experienced ecologist, in this case the USGS-BRD Ecologist will also typically be project crew leaders on sampling events. The project leader will be responsible for some data collection, some data entry, data verification, data validation, data summary, analysis, and reporting. Trained biological technicians, or crew members, will also be responsible for data collection and some data entry. Data management will be shared responsibilities among the project leader and data manager. The data manager and project leader will develop data entry forms and database features as part of quality assurance and automates report generation. The data manager is ultimately responsible that adequate QA/QC procedures are built into the database management system and appropriates data handling procedures followed.

Qualifications and Training

Qualified crew members, particularly student interns, should be oriented toward a career in science, preferably the biological sciences. Students with a biological career-track are generally less afraid of insects and crew members participating in cricket sampling events will be intimately involved with relatively large, long-legged insects. Further, scientifically oriented crew members will also be aware of the need for careful data gathering. Due to the need for underground travel and in environments with some surface relief crew members should be free of claustrophobia and relatively physically fit.

The project leader and experienced personnel will train sampling crews to conduct cricket monitoring. For new crew members, training sessions will include an orientation to the monitoring protocol, give in-office demonstrations of the less intuitive field equipment and tasks (e.g., laser assembly, image analysis, and image data entry) and on the job training such as sampling dry runs. Experienced crew members absent from the project for more than a few months will attend a sampling dry run and re-train at

image analysis and image data entry with current crew members. Once the project attains a critical mass of reliable crew members, training sessions will be conducted as needed.

VII. Operational Requirements

Annual Workload and Field Schedule

In the initial year-long test of the protocol, cave cricket monitoring will occur on a bimonthly basis. Inclement weather and personnel workloads will necessitate the scheduling of sampling dates far in advance, if possible. Monitoring efforts will require a three to four person crew. Approximately three to four half-days are required to complete cricket sampling at Mammoth Cave National Park. Two caves per team should be scheduled each field day.

Facility and Equipment Needs

The nature of cave cricket sampling work does not require special facilities beyond normal office space and equipment storage needs. Table 2.3 in SOP #2 "Pre-Sampling" is a list of field equipment needs for one crew. Since two crews will likely work simultaneously, equipment requirements will increase accordingly.

Monitoring Costs

Personnel expenses for field work are based on two crews of three to four people: an ecologist to oversee the sampling event, conduct the photo plots and act as crew leader plus three temporary biological technicians to act as field assistants. The initial year-long test of the protocol will involve eight people doing a half-day of field work, or four full days of field work once every two months, for approximately 24 field days per year. Field costs will vary somewhat from year to year based on the skill level and size of the crew. Further, the permanent sampling schedule may decrease after the year-long test of the protocol. We are currently analyzing logistic considerations and personnel expenses including staff time of biological science technicians, full-time employees, the project leader, and data manager.

Procedure for Revising the Protocol

Over time, revisions to both the Protocol Narrative and to SOPs are to be expected. Careful documentation of changes to the protocol and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis. The MicroSoft Access® database for each monitoring component contains a field that identifies which version of the protocol was being used when the data were collected.

The rationale for dividing a sampling protocol into a Protocol Narrative with supporting SOPs is based on the following:

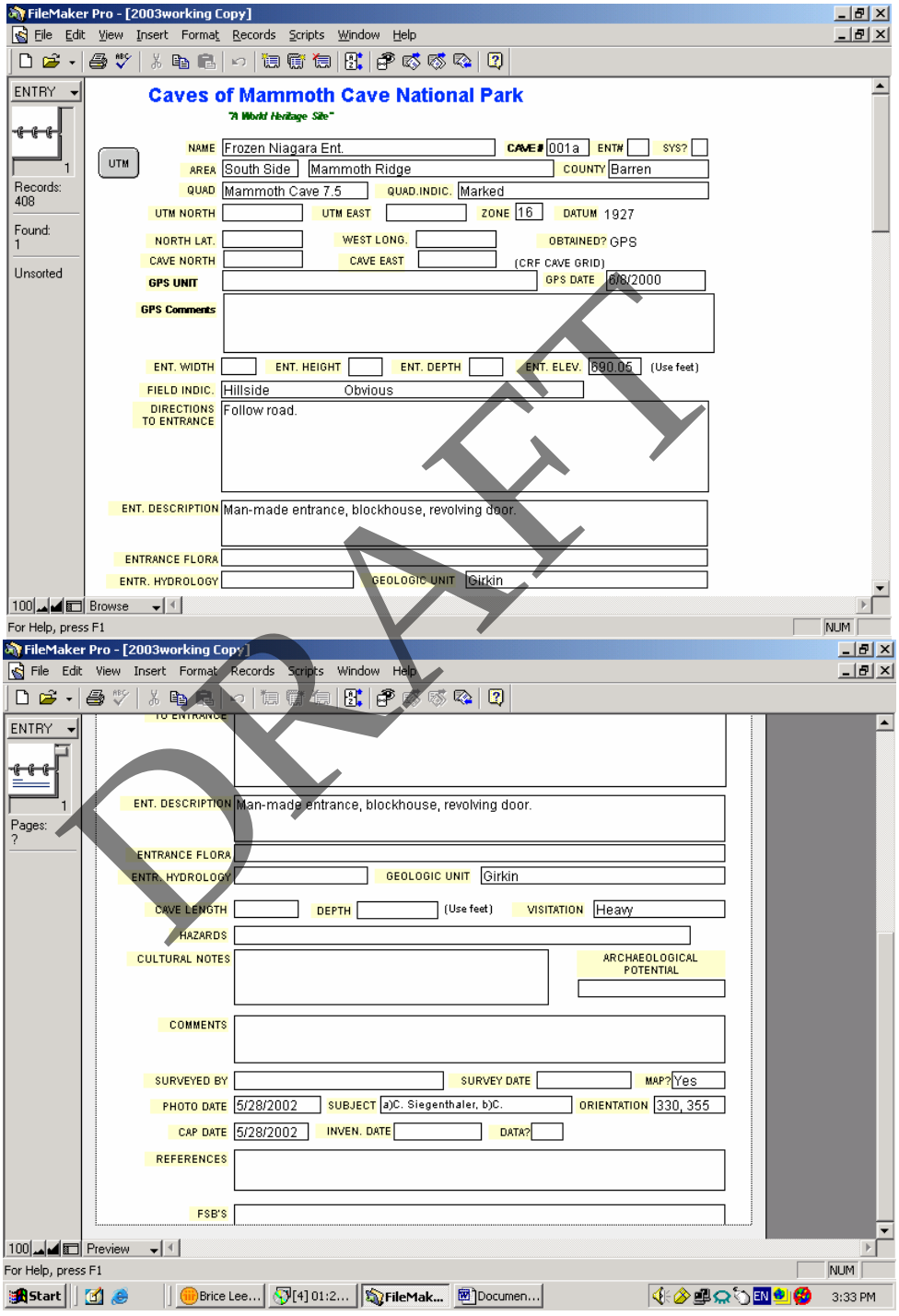
- The Protocol Narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide all of the methodological details. The Protocol Narrative will only be revised if major changes are made to the protocol.

- The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.
- When a SOP is revised, in most cases, it is not necessary to revise the Protocol Narrative to reflect the specific changes made to the SOP.
- All versions of the Protocol Narrative and SOPs will be archived in a Protocol Library.

The steps for changing the protocol (either the Protocol Narrative or the SOPs) are outlined in SOP #9 "Revising the Protocol". Each SOP contains a Revision History Log that should be filled out each time a SOP is revised to explain why the change was made, and to assign a new Version Number to the revised SOP. The new version of the SOP and/or Protocol Narrative should then be archived in the MACA-LTEM Protocol Library under the appropriate folder.

VIII. Appendices

Appendix A. Cave File Data Form



Appendix B. Field Vetting Data Sheet

Cave Characteristics for Cave Cricket Monitoring

Cave name and GPS coordinates: Cadaverous Cave
Trip time: Drive 5 min Hike 5min
Ease of access: Easy
SURFACE HABITAT:
Cave entrance aspect: South/Southwest facing

Vegetation notes (e.g., common names and/or types)

Cedar, Maple, dogwood, elm,

Forest characteristics: (e.g., open or thick undergrowth)

open undergrowth

SUBSURFACE HABITAT:
Estimate relative # crickets:

Few (less than 50)

Estimate mix of adults v. juveniles:

90% adults, 10% juveniles

Evident clusters of crickets? Guano deposits in places with/without clusters? Shoot photos.

No clustering and some old guano deposits.

Cave Ceiling Width/Height (measure or estimate) in cricket cluster areas. Give estimation of ease of sampling in this cave. Draw rough x-section or shoot photos

Cave has low ceiling. Not suitable for sampling.

Cave Length (if easily measurable)

Not easily measurable.

Appendix C. Cave Rating Example

Rating system for caves: Points awarded on best-worst scale

1. Cricket numbers: 10-5 points
2. Ceiling morphology: 10-5 points
3. Trip time: 5-1 points
4. Ease of access: 5-1 points

Wildcat Hollow Sink

1.	7
2.	9
3.	2
4.	4
E	**22**

Temple Hill Cave

1.	6
2.	8
3.	2
4.	5
E	**21**

Salts Cave

1.	8
2.	7
3.	4
4.	4
E	23

Currie Cave

1.	8
2.	8
3.	2
4.	3
E	**20**

Paw Paw Cave

1.	5
2.	8
3.	2
4.	3
E	**18**

Dennison Cave

1.	6
2.	9
3.	2
4.	2
E	**19**

Silent Grove Springhouse Cave

1.	8
2.	9
3.	4
4.	3
E	**24**

Martin Cave

1.	7
2.	6
3.	3
4.	3
E	**19**

Ice Cave

1.	5
2.	8
3.	4
4.	1
E	**18**

White Cave

1.	9
2.	8
3.	3
4.	5
E	**25**

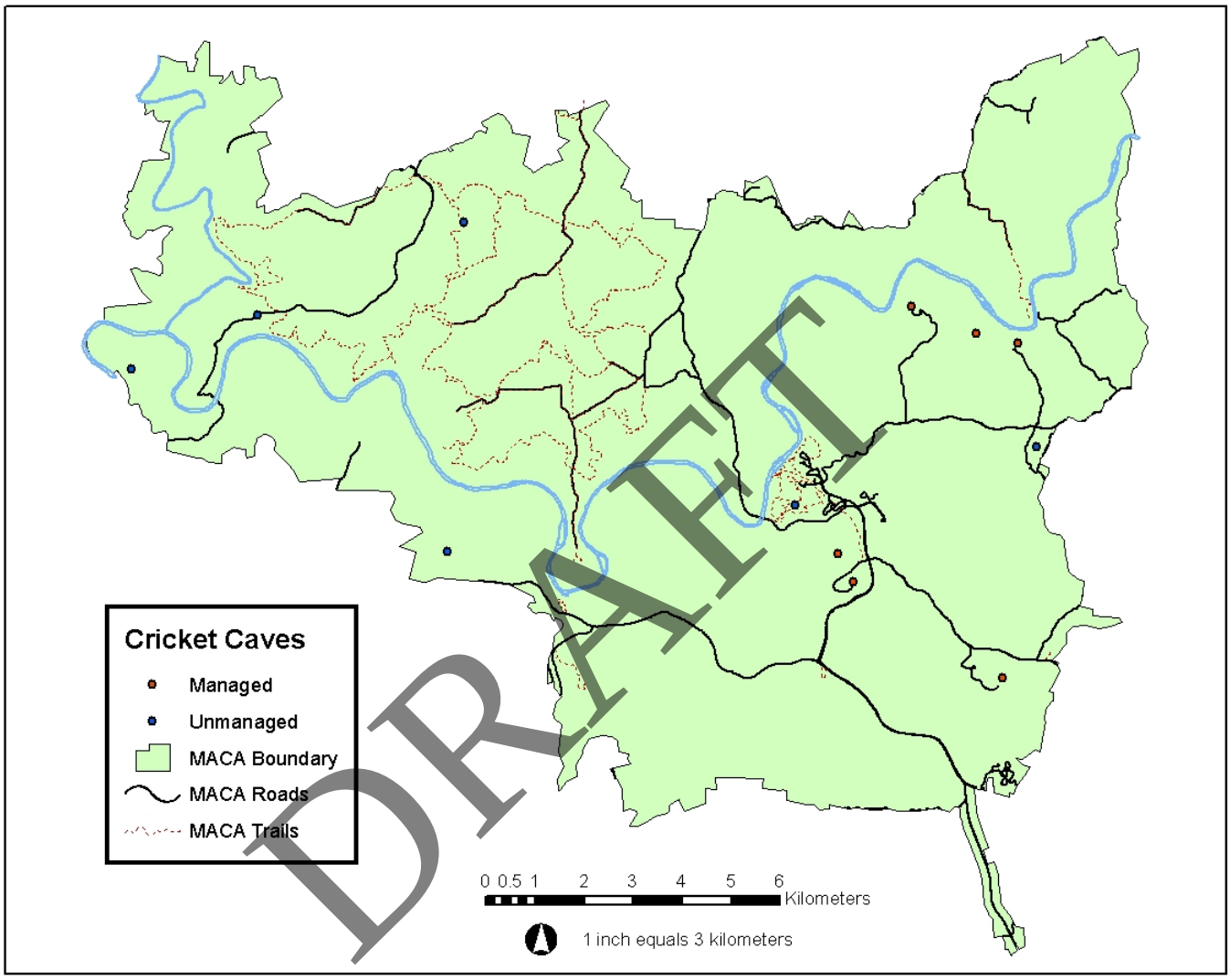
Little Beauty Cave

1.	7
2.	7
3.	3
4.	2
E	**19**

Ranked Unmanaged Caves from Best-Worst

1. **White**
2. **Silent Grove Springhouse**
3. **Salts Cave**
4. **Wildcat Hollow Sink**
5. **Temple Hill Cave**
6. **Currie Cave**
7. **Little Beauty Cave**
8. **Martin Cave**
9. **Dennison Cave**
10. **Paw Paw Cave**
11. **Ice Cave**

Appendix D. Map of Selected Monitoring Caves



Appendix E. Cave Cricket Sampling Handbook

This document is under development

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Cave Cricket Monitoring Protocol for Mammoth Cave National Park

Standard Operating Procedure (SOP) # 1

Training Sampling Crew

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure (SOP) discusses the training of sampling crew members. Implementation of this protocol requires an overall **project leader** and a minimum of two 4-person **project crews**, each with a **project crew leader**. The project leader oversees and directs project operations. Project crew leaders, permanent employees intimately familiar with field sites and years of experience employing sampling techniques, assign and direct the activities of project crews and are responsible for training sessions**.** Project crews will be comprised of both permanent and temporary personnel that exhibit some turnover rate (e.g., student interns).

Training sessions are necessary for all project crew members but particularly crew members new to the project. New crew members must undergo the entire gamut of training sessions so that they may be proficient in all activities of the protocol and therefore able to assist with any task. Types of training sessions will include: an approximately hour-long orientation session which will basically summarize this protocol, in-office demonstrations of the less intuitive field equipment (e.g., laser assembly), in-office demonstrations of image analysis and image data entry, sampling dry runs, and pre-sampling event briefings. Obviously, on the job training will also be of enormous value toward honing new crew members' skills at various protocol tasks. Experienced crew members absent from the project for more than a few months should re-familiarize themselves with project tasks by at least attending a sampling dry run and re-train at image analysis and image data entry with current crew members. Once the project attains a critical mass of reliable crew members, training sessions will be conducted as needed. Table 1 below is a more detailed list of protocol tasks that crew members need to master.

Training Location		Protocol Task
Field	Office	Use of laser equipment (SOP 3b "Field Measures: Transect-based sampling")
Field	Office	Use of compass
Field	Office	Taxa recognition (Narrative: Appendix D: Cave cricket sampling handbook)
Field	Office	Recognition of cave cricket size class/sex/body parts (Narrative: Appendix D: Cave cricket sampling handbook)
Field	Office	Camera operation (SOP 3a "Field Measures: Plot-based sampling")
Field	Office	Photographic techniques (SOP 3a "Field Measures: Plot-based sampling")
Field	Office	Thermohygrometer use (SOP 3a "Field Measures: Plot-based sampling", Appendix 3a)
Field	Office	Use of data forms
Field		Transect sampling (SOP 3b "Field Measures: Transect-based sampling")
Field		Plot sampling (SOP 3a "Field Measures: Plot-based sampling")
	Office	Image analysis (SOP 4 "Image analysis and image data entry")
	Office	Data Entry (SOP 4 "Image analysis and image data entry")
Field	Office	Proper use of the park's two-way radios

Table 1.1 Detailed list of protocol tasks in which project crew members must be proficient and their locations among project SOPs (if any). Obviously, on the job training will be an important part of the training process for all these tasks.

Cave Cricket Monitoring Protocol for Mammoth Cave National Park

Standard Operating Procedure (SOP) # 2

Pre-Sampling

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

The sampling procedure during the year-long test phase of the cave cricket monitoring protocol calls for monthly sampling trips and so there is little opportunity to lose track of sampling methodology. However, revisions to the monitoring protocol could lead to an increase in the interval between sampling trips. If the sampling intervals increase, and such changes will be noted in the Revision History Log above, all monitoring crew members should review this entire protocol, including SOPs before a sampling trip. This SOP also gives a brief description of how cave cricket monitoring should be scheduled at Mammoth Cave National Park. All of the equipment and supplies listed in this SOP should be organized and made ready for each trip into the field. Care should be taken to ensure that field notebooks are in sequence with respect to date last used. After each sampling trip, care should also be taken in the cleaning and storage of equipment, disposition of notebooks and data storage cards from digital cameras, and all data should be downloaded to proper storage media. Finally, this SOP outlines a method for the efficient utilization of time spent sampling by all crew members.

I. General Preparation And Review

Procedures:

1. Notebooks from previous surveys should be reviewed if available to identify any unique events or hazards that may be encountered. A spreadsheet for the sampling year should be prepared with pages for entry of sampling schedules, crew member names, field hours and unique happenings that may influence how the data are reported. Trip reports are based on information recorded in field notebooks so it is imperative that they are clearly organized for ease of field note entry. Thus, we developed custom pages for "Rite-in-the-Rain" field ledgers so field note entry is standardized among sampling groups (Figure 2.1).

Front Side

Cave	**Start time**
Date	**End time**
Team Leader	**T °C (Out)**
Samplers	**RH%(Out)**

Region			
Plot	Bearing	Distance(m)	T°C / RH%
1			/
2			/
3			/
4			/
5			/
6			/
7			/
8			/

	Count			
Transect	Had	Ceuth	Meta	Unk.
1a				
1b				
2a				
2b				
3a				
3b				
4a				
4b				
5a				
5b				

Back Side

Region			
Plot	Bearing	Distance(m)	T°C / RH%
1			/
2			/
3			/
4			/
5			/
6			/
7			/
8			/

	Count			
Transect	Had	Ceuth	Meta	Unk.
1a				
1b				
2a				
2b				
3a				
3b				
4a				
4b				
5a				
5b				

Comments/Observations

Figure 2.1. The front and back sides of a two-sided page from our 4 5/8 x 7", 32 leaf (64 page) customized "Rite-in-the-Rain" field ledger.

2. Prior knowledge of sampling procedures and species most likely to be encountered in the cave is essential for cohesive and efficient sampling crews. Therefore, new crew members and/or experienced crew members absent from the project for more than a few months should undergo (re)training as needed (see SOP #1 "Training Sampling Crew") and review appropriate SOPs, cave maps, and JHAs (Appendix 2a). In addition, a 'dry run' sampling trip should be scheduled before sampling begins in earnest.
3. If caves are added or deleted from the monitoring list their waypoints must be loaded or removed from the GPS units prior to the start of a sampling trip. Waypoints are the X and Y coordinates for each cave and are used to navigate to their location.

II. Scheduling Field Work

Procedures:

1. While sampling dates should be scheduled and logistics organized months in advance of sampling trips, inclement weather and personnel workloads may preclude the scheduling of sampling events to specific annual dates. Thus, backup dates should also be scheduled in advance. Time budgets for sampling trips should be worked out ahead of time to facilitate scheduling among crew members (Table 2.1). Flexibility is encouraged when scheduling however because the project leader may want to schedule opportunistically, particularly during the winter months, to take advantage of cricket's numerical response to increased temperature and rainfall. Initially, cave cricket monitoring trips are scheduled once per month over a one-year period. Based on previous entrance biomonitoring at Mammoth Cave National Park, peak numbers of cave crickets are encountered from May to June and so if the number of sampling trips decreases the remaining trips should be scheduled during these months.
2. Monitoring efforts within Mammoth Cave National Park will require a three to four person crew (ideally three people to sample and one to record data) and approximately three field days to complete (Table 2.1).
3. At least one cave couplet per crew should be scheduled for completion each field day. Determine which couplets will be best for the crew members' schedules based on their estimated travel times.

III. Organizing Supplies and Equipment

Procedure:

An equipment list should be compiled, and equipment organized and made ready well in advance of the next sampling trip. This allows time for crew members to make needed repairs, check batteries and order equipment, if necessary. Tables 2.2, 2.3, and 2.4 are a pre-event logistical checklist, a checklist of supplies/ equipment needed per crew, and a personal supply checklist for crew members, respectively.

Day	Crew	Cave Couplet	Travel Times
1	1	Frozen Niagara/ Silent Grove Springhouse	4 hr.
1	2	White Cave/ Wildcat Hollow Sink	4 hr. 40min.
2	1	Austin/ Floyd Collins Crystal	4 hr. 20 min.
2	2	Salts/ Great Onyx	3 hr. 40 min.
3	1	Temple Hill/ Currie	4 hr. 30 min.
3	2	New Discovery/ Carmichael	3 hr. 20 min

Table 2.1. Time needed for two four-person crews to complete one cave couplet per day over a three-day period. Travel times include drive time to and from Science and Resources Management (SRM) offices, ca. 1 hr. 30 min. sampling time per cave, and drive time between caves.

Number Required	Description
	Pre-Event Logistical Checklist
1.	Schedule monitoring crews with caves and ordered routes in advance
2.	Reserve appropriate number and type of vehicles in advance
3.	Go through supplies/equipment checklist
4.	Check all appropriate equipment for battery condition—replace as needed
5.	Review appropriate Job Hazard Analysis (JHA) Form (Appendix A) and sign book
6.	Project leader or designated crew leader(s) conduct pre-sampling training and briefing for crew members, as necessary, on Day 1 of sampling session
7.	Fill out Cave Entrance Request Form for all non-artificially lighted caves and file one copy with Ranger Division---Project leader keeps originals in file
8.	Obtain keys to cave gates/doors and road gates
9.	Establish surface watch
10.	Sign out crew with destination, vehicle, and approximate return time on dry erase board in office
11.	Perform general pre-trip vehicle inspection (check: first aid kit, fuel level, oil level, tires, spare tire and changing equipment, lights, and wipers)

Table 2.2. Logistical checklist for Cave Cricket Monitoring

	Number Required	Description
		Supplies/Equipment Checklist (<u>Per</u> Crew)
☐	1	Portable Camera Tripod
☐	1	Laser assembly
☐	1	Spare Laser
☐	1	Monopod (optional, as desired)
☐	1	Digital camera with case, battery, and memory card assembly
☐	1	Measuring Tape ≥15m (cloth or metal)
☐	1	Pre-printed data forms on "Rite-in-the-rain" paper with clipboard
☐	1	Rite-in-the-rain notebook
☐	1	Mechanical pencil(s)
☐	1	Backpacks
☐	1	Equipment bag
☐	1	Magnetic Compass
☐	1	Thermohygrometer (Testo Model 445) w/ probe and cable
☐	1	Rigid, collapsible metal pole (≥1.5m)
☐	1	Extra batteries for all battery operated equipment
☐	1	Appropriate 'baseline chains' for scheduled caves and region
☐	1	GPS unit with all cave entrance waypoints pre-programmed
☐	1	First Aid kit
☐	1	Two-way radio
		Crew Leader's Signature:_____ Date:_____

Table 2.3. Field equipment checklist for Cave Cricket Monitoring

	Number Required	Description
		Personal Supplies/Equipment Checklist
☐	1	Helmet with lights
☐	1	Knee pads
☐	1	Water bottles and lunch (as necessary)
☐	1	Work gloves (as necessary)
☐	1	Hand-held flashlight for back up light source
☐	1	Extra batteries for all personal battery operated equipment
☐	1	Coveralls
☐	1	Backpack
☐	1	Snake chaps (as necessary)

Table 2.4. Personal field equipment checklist for Cave Cricket Monitoring

IV. Distribution of Sampling Tasks Among Project Crew Members

Because cave crickets are easily disturbed the project crew leader must choreograph the activities of project crew members somewhat carefully during the sampling process. Subsequently, data quality and reliability, in particular plot data, would suffer even before it can be collected. Thus, effective data collection is not a linear process where the entire sampling crew concentrates on one sampling task at a time.

Experience during the initial testing phase of data collection for this protocol suggests each sampling crew should be broken up into three sub-crews with different data collection tasks: a two-person (i.e., crew leader and crew member) photo crew, a one-person air quality crew and data recorder, and a one-person mapping crew. Each of these crews occupies a different part of the cave while they are performing their assigned data collection tasks; though generally, the air quality crew and mapping crew may occupy the same region of the cave during a sampling event. Thus, photographic plot data and transect data may be collected with a minimum of disturbance to cave crickets, data reliability is maximized, the sampling crew's overall time on task is minimized, and the sampling process is much more efficient.

What follows are suggestions for the choreography of the three crews during the sampling process both inside and outside the cave. The methods used to perform each of the three sub-crews' data collection tasks are defined in (SOPs #3a, 3b, and 4). Refer to Appendix 2b for a diagrammatic representation of these directions.

Step 1.
The air quality (AQ) sampler takes a reference T/RH sample outside the cave and reports the data to the mapping (M) crew member who records the data. When they are finished with their reference data, the crew members wait outside the cave for the photo crew to signal they are finished. Meanwhile, the photo crew enters the cave to scout plot locations and shoot digital images in Region 1 (see SOP #3a "Field Measures: Plot-based sampling"). When they are finished in Region 1, the photo crew signals the AQ and M crew members waiting outside.

Step 2.
The photo crew goes to Region 2 to scout plot locations and shoot digital images. The AQ and M crew members enter the cave to begin their work in Region 1 (see SOPs #3a and 3b). At this point the AQ takes over possession of the field notebook and becomes the data recorder for the remainder of the sampling event. The AQ crew member takes T/RH readings at the marked photographic plots in Region 1 and records them (Appendix 3a, SOP #3a "Field Measures: Plot-based sampling"). At the same time, the M crew member sets up the laser tripod at the landmark in Region 1 and reports each plot bearing and plot distance to the AQ crew. The AQ crew member should also help the M crew member measure plot distances from the landmark.

Step 3.
At this point in the sampling process there is a shift in crew activities because the photo crew has completed their sampling tasks. Thus, the photo crew splits up and each member performs separate tasks to assist the AQ and M crews. The crew leader from the photographic sub-crew joins the M crew and assists in setting up and operating the laser transects in Region 1 (SOP #4 "Transect-based sampling"). The other crew member from the photo crew assists wherever needed for the remainder of the sampling period. The AQ crew enters Region 2 and takes T/RH readings at the marked photographic plots and records them. The M crew gathers transect data in Region 1 and reports their results to the AQ crew.

Step 4.
The AQ crew continues to take T/RH readings at the marked photographic plots in Region 2 and record them. Meanwhile, the M crew members set up the laser tripod at the landmark in Region 2 and takes plot bearings, measures plot distances and report their results to the AQ crew. Finally, the M crew moves to Region 2 and gathers transect data and reports their results to the AQ crew. Generally, the two data gathering crews should finish their sampling tasks at the same time. All sub-crews then leave the cave and travel to the second cave in the couplet and repeat the sampling process.

Appendix 2a. Job Hazard Analysis Form

DATE: 9/20/2002 JOB TITLE: Field work in caves JOB LOCATION: Caves FILENAME: fldwrkcv.jha.doc	PREPARED BY: Kurt Helf TITLE: Invertebrate Ecologist DATE WORK IS PLANNED TO START:
APPROVED BY: (Division Chief) Mark DePoy DATE:	CONCURRED BY: DATE:

SAFETY ITEM	PROCEDURE	RESPONSIBILITY
Loss of light and hypothermia	Bring at least three separate sources. An LED flashlight will outlast you. Carry and extra layer of wool or high tech material, and a balaclava in your helmet liner. A garbage bag, a small piece of foam pad, and chemical heater you are ready for a bivouac.	Individual and immediate supervisor.
Accidents	Far from entrances or developed trails, cave in teams of at least four people. Team members must be reasonably matched in skills and fitness. In case of accident leave one party member with affected person, and send other two for help. Ensure ranger activities and surface watch is aware of activity location. No 'self rescue' or assist is allowed. All transport must be done by responding medical service. Carry compact first aid kit.	
Passages with vertical exposure	Inspect ropes and slings for wear; replace sooner than you think is absolutely necessary (all fibers in webbing are exposed to abrasion, unlike kernmantle ropes). Inspect teeth of mechanical ascenders for wear; keep a prussik 'quick draw' in case of ascender failure. Cross a drop unsecured only if you are sure that the moves needed are well within your skill level; make sure nobody is below.	
Flooding/storms	Check weather forecast. Base level passages, shaft drains, and even shafts can become impassable or unlivable in a matter of minutes to hours. Consider soil saturation levels in concert with weather forecast. Take note of upper level refuges from flood along lower level routes. Cave entrances can be prone to lightning; if waiting out a storm then stay hundreds of feet in and periodically check storm status.	
Fatigue	People in good physical condition need less water and are less prone to injury. Push your endurance limit in gradual increments. Avoid overloading your pack, be creative to reduce weight and bulk.	

Appendix 2b: Diagram of Suggested Sampling Crew Choreography

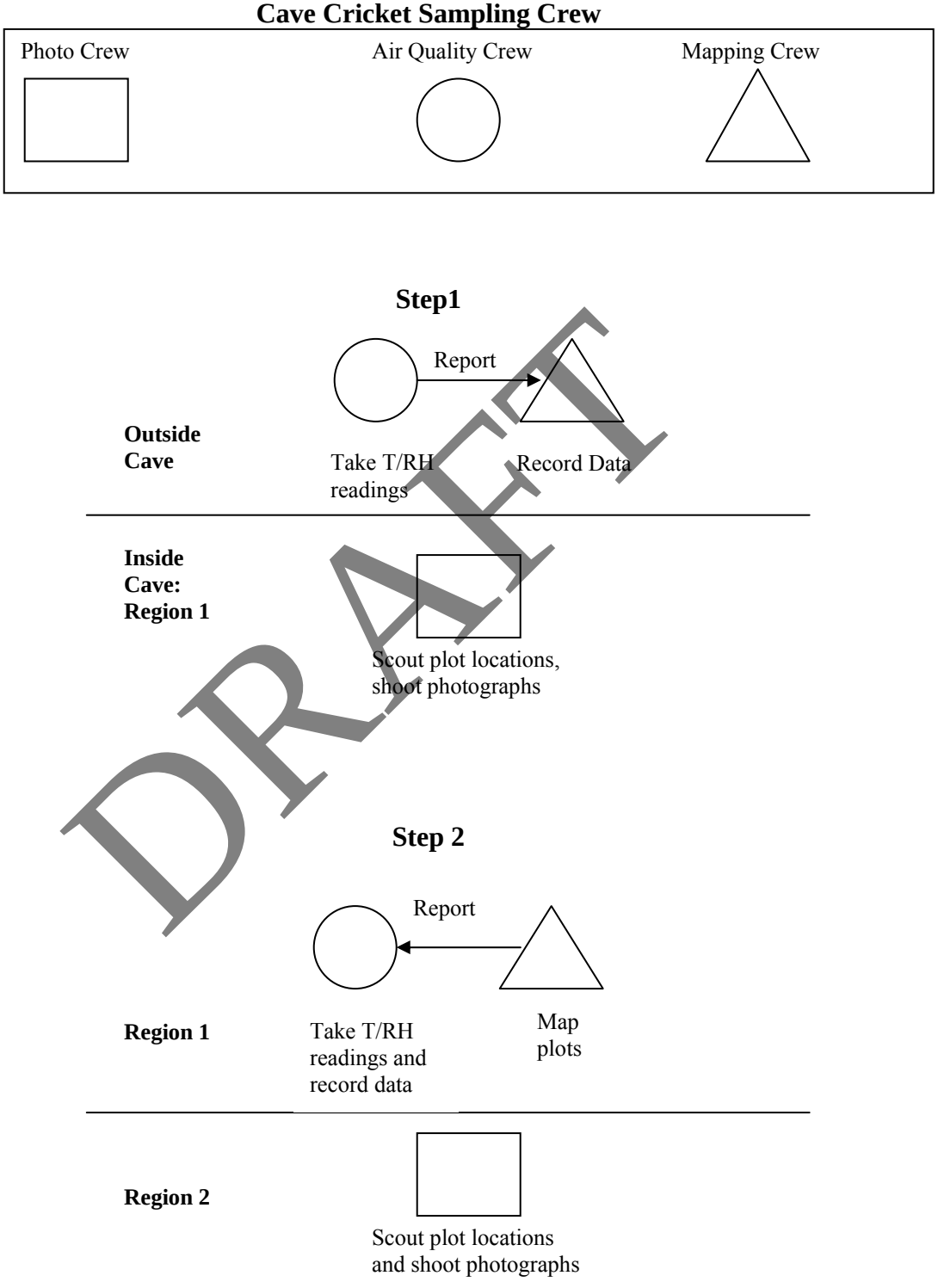


Figure 2.2. Suggested sequence and choreography of sub-crew activities while sampling. Different symbols indicate sub-crews and arrows indicate interaction between/among sub-crews and/or data reporting.

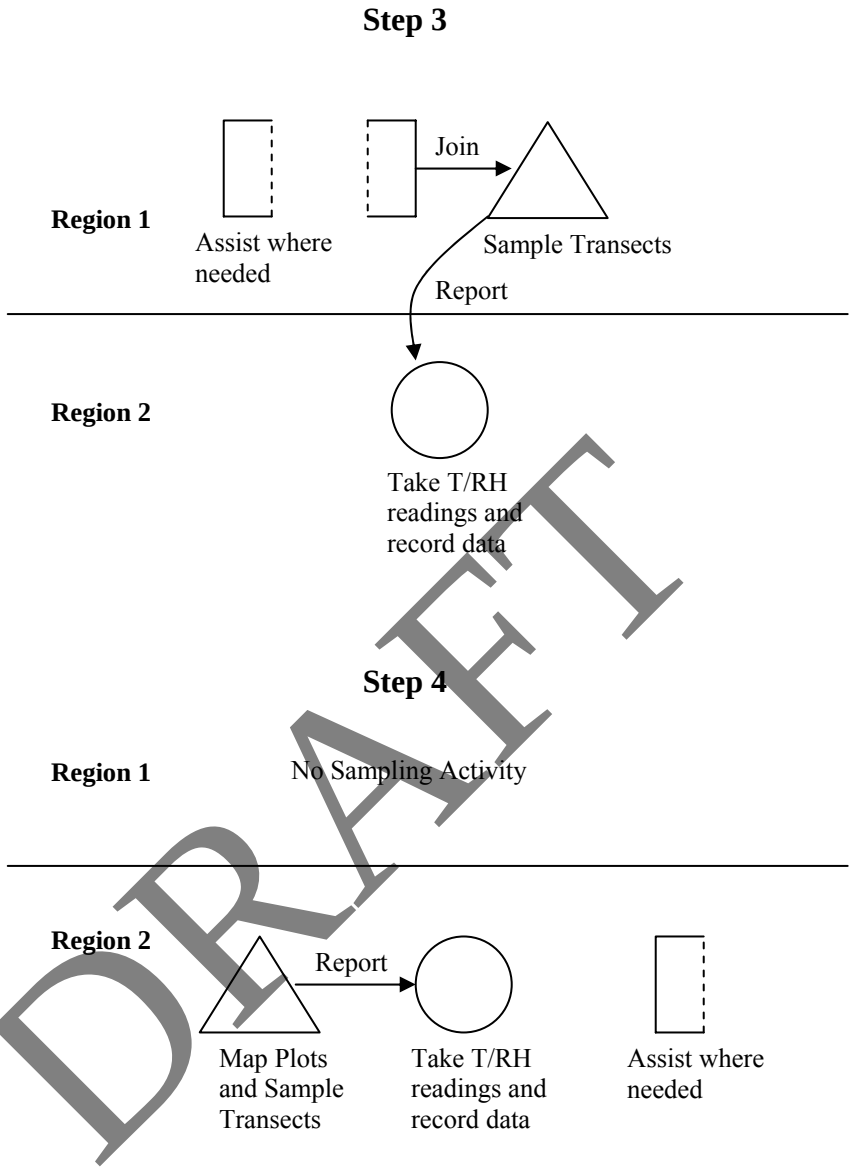


Figure 2.2 (continued). Suggested sequence and choreography of sub-crew activities while sampling. Different symbols indicate sub-crews and arrows indicate interaction between/among sub-crews and/or data reporting.

Cave Cricket Monitoring Protocol for Mammoth Cave National Park
Standard Operating Procedure

Standard Operating Procedure (SOP) # 3a

Field Measures: Plot-Based Sampling

Version 1.0 (December 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure (SOP) gives step-by-step instructions that project team leaders and team members should follow to perform the plot selection and photography, plot mapping, and air temperature and relative humidity measurement elements of a cave cricket sampling event at Mammoth Cave National Park (MACA), KY. This SOP describes procedures for: (1) Readying and operation of the digital camera, (2) Selecting cricket aggregations and plots in a cave region, (3) Photographing plots, (4) Polar-coordinate & distance mapping of photographed plots, (5) Measurement of air temperature and relative humidity at cave-entrance and plot locations, and (6) Filling in the field notebook data form (Figure 3a.6.1). A checklist summarizing these steps and their proximate order-of-performance is provided in Appendix B of SOP 2 “Pre-Sampling”.

Prior to conducting a cave cricket sampling event, all personnel involved should review this SOP (3a), SOP 3b (“Transect-based Sampling”), the related Job Hazard Analyses (JHA’s) and follow all safety guidelines (Appendix A, SOP 2, “Pre-Sampling”).

General Sampling Approach:

Monitoring of cave cricket populations will involve use of two general sampling methodologies: plot-based photographic recording and sampling for population structure parameters, and estimation of relative abundance and density using transect visual sampling. The field data-collection elements will be accomplished in six 3-day sampling events scheduled to occur at 2 -month intervals in a year. Sampling events will occur in the first week of each sampling month (FEB, APR, JUN, AUG, OCT, and DEC). Twelve caves (6 highly-managed and 6 less-managed or natural caves) will be sampled in each event using two 4-person project teams. On each day of a sampling event, each project team will perform all steps described in both SOP 3a (“Plot-based Sampling) and SOP 3b (“Transect-Based Sampling”) in 2 regions in each of 2 of the 12 caves. Transect and plot sampling will be performed in tandem by the project team in a staggered and “choreographed” manner where team members will form temporary “task crews” to implement

specific tasks, and dynamically move or switch to other tasks as needed and as members become available through completion of previous work. All field sampling elements are scheduled to be performed between 0700 and 1200 hours of each sampling day. All sampling tasks within a cave are expected to be completed within approximately 1.5 hours, in most cases; additional time may be needed if a cave presents unusual conditions or difficulties in performing one or more specific sampling tasks. The digital-image analysis and image data entry elements of plot-based sampling, described in SOP 4 ("Digital Image Analysis and Image Data Entry"), will be performed in the MACA project office after all field elements have been completed for the sampling event.

Note that transect-based sampling in a cave region should start only after plot photographing has been completed for that region. Refer to "Task Scheduling" in SOP 2 ("Pre-Sampling") for description of overall order and coordination of sampling tasks among and within caves. The project team leader is responsible for supervising and coordinating the orderly and sequential performance of sampling tasks in the cave to ensure that all tasks are completed in an efficient manner and without undue interference with other co-occurring tasks.

Plot-Based Sampling:

The field elements of plot-based cricket sampling (plot selection, plot photography, plot mapping, and collection of plot-associated air temperature and relative humidity) will be performed in 2 regions within each cave sampled on an event. Plot-based sampling involves subjective selection and photographing of eight (8) "higher-density" aggregations of crickets in each cave region. Each cricket aggregation will be sampled by locating and digitally photographing one "plot" centrally within the aggregation, yielding a total of 8 plots per cave region, and a total of 16 plots per sampled cave. At least two digital images ("normal" or "fine" resolution "jpg." images) will be taken of each plot, in most cases. These images will be processed following completion of field sampling using the image analysis steps described in SOP 4 ("Image Analysis and Image Data Entry"). Cricket aggregations (represented by photographed plots) are dynamically located within cave regions and move or re-distribute within regions over time. The locations of plots will be mapped in each sampling event using a polar-coordinate-and-distance mapping system to provide a dynamic map of higher-density aggregation locations and movement over time. Plots will be mapped with respect to the location of the permanent, fixed "Landmark" point established and mapped within each sampled cave region. This fixed region landmark will also be used as the location reference point for positioning and orienting the virtual transect array used for transect-based sampling, as described in SOP 3b ("Transect-based Sampling"). Air temperature and relative humidity (T/RH) will be measured near the cave substrate in each sampled plot, using the rapid-response Thermo-hygrometer. T/RH will also be measured and recorded outside the cave entrance at the start of the cave-sampling run, to provide a surface conditions reference for comparison with in-cave conditions. T/RH data will provide a plot-based physical environment correlative component in the cricket monitoring design.

I. Readying and Operation of the Digital Camera

Figure 3a.1.1a. Nikon Model 5400.

Figure 3a.1.1b. Back of Nikon 5400 showing the view screen

Photography of cricket aggregations and plots is accomplished using one of 2 models of Nikon digital cameras (Model 4500 or 5400) (Figure 3a.1.1a, 1b. Model 5400 Digital camera). These cameras are 5.0 mega-pixel, auto-focusing, multi-function digital cameras with integral strobe flash, optical and electronic zoom, and close-focus or macro-mode capabilities. Both models utilize a standard removable memory "flash-card" for image recording, and an interchangeable, rechargeable Lithium battery for power. Standard camera configuration for use in plot photography will be: picture resolution is set on "normal" or "fine" (creates a ca 1.0 MB (mega-byte) "jpg" image), auto-focus feature is enabled, focus mode is set to "macro", and flash feature is set to "always-on". All other image controls and parameters should be set to "normal" and un-biased, to support a normal image quality (see Nikon Camera Operator's Manual for specific setup procedures for these parameters). The specified flash-card capacity is 256 MB, which will support recording approximately 220-240 "normal" jpg images (One sampling day will yield approximately 50 images per cave, for a total of about 100 images per day per team. Images will be down-loaded from the memory card after each day's sampling). Digital cameras are impact and moisture-sensitive, and should be carried and stored in a padded camera case when not in use. The camera comes with an attached lens cap, which should be secured on the lens face at all times when the camera is not in use. A spare battery and a spare 256 MB flash card should be carried into the field on all field trips. Team members should consult the Nikon Camera Operator's Manual available in the MACA project office for technical details and instructions on setting camera features. Digital cameras are both essential field instruments and expensive assets- treat them with respect and handle them with care! Each project field team should perform the following camera checks and preparation steps within one week of departure to the field, and again just prior to departure for sampling:

Procedures:

<u>Pre-Departure Setup and Preparation</u>

1) Charge the camera batteries with the battery charger supplied with the camera. Consult the Nikon Operator's Manual for this procedure. Fully charging a battery will take

approximately 1 – 2 hours, depending on current battery charge level. At least two batteries should be charged up and ready for use during a sampling session.

2) Insert a freshly-charged battery into the camera, ensuring that battery is fully-seated and that the battery access door is closed and secure.

3) Check the status of the camera memory flash-card installed in the camera. Ensure that the card is empty and ready to record images. To check card status, set camera power switch to "on", allow the camera to warm up and perform its system checks (about 15 seconds), and then depress the "quick" button twice. This will cause the camera to access the card, and, if the card is empty, but ready to record images, the camera will indicate a message of "no images contained on card". If images are present, an image will be shown. In this case, either obtain another card, or delete all images from the current card using the image-delete commands (see Nikon Operator's Manual for this procedure). Card failure will be indicated if it occurs, in which case, another card must be obtained.

4) Ensure that all exposure parameters and controls are set up for normal operation, normal "jpg" image resolution, "Macro-close focus" mode, "always-on" flash mode, and auto-focus enabled using the model-specific procedures described in the Nikon Operator's Manual. Ensure that the internal camera clock is set for the correct date and time (CST) so that this information will be properly recorded in the image data files.

5) Check camera zoom, auto-focus, flash and lens functions by taking several trial pictures while at the office. Verify that the camera will reliably perform all functions as expected. If one or more functions do not work, you must notify the project team leader of the equipment failure and locate another camera for field use. Once performance testing is complete, be sure to delete any test images so that memory card space is fully available for field photography, and turn the camera power switch to "off". (Note: camera will automatically shut down after a short period- 1-5 minutes, but failure to power-down camera can result in significant use of battery power.)

6) Prepare the camera for transport and use. Ensure that camera neck strap is securely attached to camera and adjusted to user preference. Place cap on lens, and pack camera, spare battery and spare memory flash-card in camera bag. Securely close camera bag. Ensure that camera bag neck strap is securely attached.

<u>At Sampling Site</u>

1) When you arrive at the cave to be sampled, remove the camera from the camera bag, suspend the camera around your neck using the camera strap, and switch camera power to "on". Once camera has powered-up, remove and stow the camera lens cap.

2) Perform a quick check of all camera functions and proper settings (zoom, auto-focus, macro mode, flash ready, battery and card ready, etc.) that you checked in the pre-departure steps. If all functions and modes are working as expected, you are ready to start taking pictures. If any settings need adjustment, be sure to perform these adjustments now. Of particular note:

ensure that the camera flash function is still set to "always-on" and exposure mode is set to "macro". Failure to have these properly set will prevent your successfully focusing on or capturing crickets, and thus, may lead to a lost plot opportunity, if crickets depart before deficiencies can be corrected.

3) Repeat camera function, mode and battery status checks frequently as you go from plot to plot. Flash photography can quickly exhaust the battery. As battery charge depletes, camera functions can become increasingly delayed. When you change a battery, it is imperative that you check for correct camera mode and function settings, as these may be automatically changed to default values by the camera after power is lost. Likewise, if the camera automatically shuts down, as it will do if not actually being used (and after shorter waiting times as battery charge depletes), be sure to check camera function and mode before attempting to take an important (plot record) picture.

Selecting, marking and photographing cricket aggregations and plots within a cave region

Initial site surveying, cricket aggregation and plot identification and photography within a cave region is performed by 2 project team members who will form a temporary **photo-crew** composed of the **photographer** (crew leader) and his/her **assistant**. The photo-crew will perform all of the tasks directly related to identifying and photographing plots. Other tasks, such as collection of T/RH data, mapping of photographed plots, and transect sampling, will be initiated by the other project team members in an overlapping sequence of events starting up after plot photography is largely complete within the first cave region. Once all plots in both regions have been photographed, photo-crew members will shift onto other tasks, as needed (i.e., to transect sampling, or to plot mapping). It is preferable that the photo-crew be the first project team personnel to actually enter into each cave region to be sampled, so as to avoid undue disturbance that can result in dispersal of crickets and lost plot sampling opportunities. The photo-crew will perform the first phases of plot location and photography prior to other team members entering into a region to perform either plot-related tasks or transect sampling. Five closely-linked tasks are performed by the photo-crew in close succession in a cave region: survey the region to select cricket aggregations, prepare the focus-target for marking a plot, assess the prospective plot for "best" photographic approach, take plot pictures, and review plot pictures.

II. Survey the cave region to locate the 8 best cricket aggregations for plot

Procedures:

1) Before entering the first cave region (proximal to the cave entrance), the photo-crew members should perform a quick check of all personal and project equipment. Check helmet- and flashlights, and ensure the camera and focus-target are ready. Crew members will turn on helmet or headlamps, as needed (for some highly-managed caves, cave lighting systems may already be on when sampling begins, negating immediate need for personal lights).

2) Enter the cave region to begin the survey to locate likely higher-density cricket aggregations for photographing. Perform a quick (ca 5 minutes) walk-through inspection of the region to locate the 8 "best" aggregations that will be recorded in plots for the sampling run. This

walk-through should follow along a circular or zig-zag path through the cave space that will allow either or both crew members to reasonably inspect and observe most likely surfaces and areas within the cave region. Perform this survey with a minimum of talking and incidental noise, and use moderate light to quickly inspect likely ceiling, upper-wall and under-ledge surfaces for cricket aggregations or groups (cave crickets are most likely to be found on upper walls and ceilings, and rarely are found on the cave floor). Use of minimum lighting, shorter examination periods and less noise and limiting abrupt movement near observed aggregations are important to reduce disturbing crickets prior to photographing. While performing the walk-through, keep a mental tally of aggregations observed, noting general size and appearance, accessibility and location of each aggregation. Crew members should frequently check with each other during the survey and examine the same areas and aggregations. Note: Following the same general survey route on subsequent sampling events is OK, providing crew members emphasize examination across the entire region, and consciously avoid focusing strongly on areas where cricket aggregations have been found in previous sampling events.

3) After the survey walk-through is complete, the **photographer** will select the 8 "best" plots from among his/her mental list of observed aggregation sites. Plot selection should be based on the "best plot criteria" defined below, and performed in (quiet and brief) consultation with the assistant. Criteria should be considered in the order listed, with criterion (1) being the most important factor in decision-making. The photographer/crew leader will determine the order the 8 plots will be photographed in. This order will be the plot identification order that will be used for all other plot-related sampling and data-recording for this region in this sampling event. Note: It is likely that regions and caves will offer few good potential plots in some sampling events. In such cases, the photo-crew must "use what they can find and safely use", regardless of meeting any selection criteria.

Criteria used to select the "best" plots for photographing include:

- (1) Perceived aggregation **size and density** (larger groups and tighter packing are "better").
- (2) Perceived **cave substrate contrast and texture** (smoother substrates with more uniform and lighter color offer better contrast with crickets, while very convoluted substrates may present backgrounds on which crickets are difficult to see).
- (3) Perceived **plot accessibility** (aggregations located deep inside cracks or under low ledges may be very difficult to approach). Note: Cave features are sensitive resources, and access must always consider possible damage to cave features, such as speleothems.

Personal safety is an important consideration in photographing plots in cave. If there is no place for the photographer to safely stand, kneel, crouch, sit or lie in, the plot cannot be reliably photographed, and should not be attempted. The primary objective in plot selection is to identify the 8 largest or densest, yet reasonably accessible, aggregations in a cave region. **In-situ evaluation of apparent cricket population structure** within prospective plots should be strictly avoided, as this will add subjective variation in choice of plots to photograph, and thus, to measured structure parameters. Finding aggregations "rich" in larger (size 3 and 4) crickets are easier to see than are those rich in sizes 1 and 2. It is recommended

that the photo-crew ensure that the survey includes looking for aggregations of smaller, as well as larger crickets.

III. Photographing a plot in a cricket aggregation

The photo-crew will perform a quick stepwise process to digitally photograph each of the 8 "best" plots identified in the region survey. The critical objectives in this process are (1) to obtain at least one adequate image of each plot, and (2) support later collection of other data relevant to the plot sampling elements of this protocol. For this protocol, an "**adequate image**" is defined as being one that has captured a relatively larger number of crickets with sufficient clarity and resolution to enable reliable and accurate analysis of the image for cricket-related data. Collection of adequate images is accomplished by performing the described steps of the photographic process using the guidance provided on photographic techniques and technical considerations leading to obtaining "good" pictures. Support for subsequent data collection at photographed plots will be provided by placing the numbered **plot label sticker** at or near the plot site following completion of photography. The plot label sticker will provide a temporary landmark to enable other project team members to accurately and reliably locate and sample the photographed plots. While successfully photographing cricket plots is a relatively easily-learned routine, performance of all steps should be practiced prior to each sampling event, as they represent a series of more-or-less time-sensitive actions that must be rapidly and smoothly performed in sequence to achieve the objective (an adequate image of the plot) while avoiding disturbing the crickets. In general, photographing of cricket plots in a cave region should start at the arbitrary "Plot # 1" determined or selected by the photographer.

Procedures:

Pre-Departure Preparation

1) Prepare a set of 8 **plot-label stickers** for each cave region the project team and photo-crew will sample in the event-day. Plot-label stickers are prepared from small (recommended size is about 3.0 x 4.0 cm), pre-gummed "sticky-notes". Use pale yellow, blue or pink sticky notes to provide better color-contrast against cave substrates. To prepare the plot labels, position the pad of sticky notes with the gum strip running across the top side of the notes, and write in large, bold characters 2 digits to identify a region and plot on each note with a wide-chisel-tip black permanent marker pen ("magic marker"). Each set or pad will have eight pages or stickers, one for each plot in the region. Numbering will be in a digit-hyphen-digit format, with the first digit indicating the region (1 or 2) and the second the plot (1 to 8). Pages will be numbered in sequence, from plot 1 to plot 8, so that stickers can be pulled off in numerical order for use in the field. Note: plot label sticker pads may be prepared far in advance, as they are not cave-ID-specific. The project team will typically need two "region 1" pads, and 2 "region 2" pads for each sampling day (assuming sampling 2 caves per day).

Photographing a cricket plot in a cave

1) Ensure that the camera is ready in all respects to take a picture. Ensuring camera readiness prior to examining prospective plots will allow the best opportunity to obtain at least one

adequate picture, as crickets may start to disperse due to disturbance from crew members setting up and taking a picture. Check that camera power is "on", lens-cap is detached, lens is clean and unobstructed, view-screen is on, flash is set to "always-no delay" (arrow icon), framing mode is set to "macro" (flowers icon), and that the "zoom" and auto-focus features are operational.

2) Prepare the **focus-target device**. Check that all sections of the rod are snug and that the focus-target head is secure and adjusted to the desired angle. Adjust the rod length as necessary by adding or removing threaded sections. Next, peel the top plot-label sticker off of the sticker pad and position it on the target-focus head. Be sure to position the sticker so that the numbers are "right-reading" when the target head is held up in its position within the plot. Press the sticker firmly onto the target head, so that it will not flap or slide around or drop off during use. Be sure to avoid placing the sticker so as to obscure the ruler bar (size scale) on the target head, as this scale will provide important sizing information within the captured image. A "correct sticker placement" is shown in Figure 3a.3.1. Note: Plot-labels should be used in their numerical sequence, which will become the plot sampling sequence, in most cases. Preparation of the focus-target is performed by the **assistant** in coordination with the **photographer.** While the focus-target is being readied for use, the photographer should start performing the next step, assessment of the prospective plot, to visually compose a good picture.

Figure 3a.3.1. Focus-Target "Head" with a centimetric ruler and the properly-positioned Plot-Label Sticker. The number "1" is the region, "2" is the plot number.

3) The photographer will carefully but quickly scan the prospective plot to determine his/her "best" photographic approach (camera angle, frame orientation, position of focus-target in area) to obtain the desired adequate plot image. This step is a discretionary and subjective process performed by the photographer using his/her expertise and familiarity with the several factors that can influence picture quality. While assessing the plot, care should be taken to avoid shining excessive light on crickets, and to limit rapid movement close to the aggregation to be photographed. Perform this step as expeditiously as possible, as crickets may rapidly become alarmed and start to disperse, resulting in lost opportunities to adequately photograph the plot. Once the photographer has accomplished this plot

assessment and feels ready to proceed, s/he will generally promptly transition to positioning the focus-target and setting up to take the picture.

4) The photographer next determines where s/he wants to position the focus-target relative to the aggregation/plot to be photographed. Ideally, the target should be positioned so as to lie at the bottom of the image, and to be "right-reading" (readable when the image is normally viewed as a landscape). Digital camera auto-focus features generally use the higher-contrast item located in the center of the view-screen image as the primary target for focusing on. It should also be noted that cave substrates (and crickets) do not usually provide adequate contrast to support auto-focusing by digital cameras. The focus-target device provides a high-contrast item that a camera may easily "see" while attempting to auto-focus. In practice, this means that the camera should be aimed directly at the focus-target while focusing, even if the target is not in the center of the image one wishes to capture. The photographer may use either of two general options to solve this dilemma: One is to position the focus-target in the center of the desired plot, focus on the target, "freeze" the camera focus setting, manually move the target off to the plot-edge, and expose the frame. Alternatively, position the focus-target on the edge of the desired plot, focus on it in that position, "freeze" the camera focus, and then shift the camera to properly frame the desired plot, and take the picture. Both routes involve careful and coordinated movement of either the focus-target and/or the camera, and should be practiced before any sampling event.

5) In most cases, the assistant will illuminate the focus-target while the photographer positions it and focuses his/her camera. Illuminate the target with moderate light from a focused flashlight, but avoid excessively bright light, and avoid flashing and abruptly moving the light around in the cricket group. Moderately lighting the target will enable the photographer to quickly focus and take the picture. Lighting should be done in careful and smooth coordination with photographer. In the case where only one body can physically approach or access the plot, the photographer will have to illuminate the target him/herself using a flashlight or helmet-light.

6) The photographer "takes a picture" of the selected plot. Use the illuminated focus-target to set camera focus and adjust framing for a picture of the plot. "Lock-in" a focus depth or point by allowing the camera to "see" the focus-target and self-focus for several seconds, followed by partially-depressing the shutter release to "freeze" or hold the camera's current focal setting. Freezing the focus will allow the photographer to quickly adjust the camera position, angle, distance and orientation to the desired plot to better compose his/her picture. If the assistant is illuminating the focus-target or the plot during this process, the photographer should verbally notify the assistant to turn off or redirect his/her light ("OK", or "ready"), prior to recording the image ("taking the picture"). The added illumination may distort or degrade the final image contrast and quality. If the photographer is also performing target illumination, s/he should redirect his/her light prior to taking the picture, if possible. It is important to ensure that the frame can adequately capture the desired cricket group. Adjust camera zoom and adjust camera distance from target to maximize number of crickets captured in the image/frame, adjust camera angle to become more perpendicular to the target cave surface, and adjust or rotate frame orientation to best capture desired grouping. Once

focus is achieved and the frame or image is composed, take the picture and then promptly proceed to the review step.

7) Review the plot image for to determine whether it meets criteria for being an "adequate image". Both the **photographer and assistant** should promptly review the image to check for focus, color and contrast, and adequate capture of the cricket group (numbers of individuals) and available viewing resolution (ability to see details on individuals). View a newly-recorded digital image by pushing the "quick" button on the Nikon 5400 twice, which will result in a full-frame image becoming visible in the view screen (see Figure 3a.1.1b. Photograph of Nikon 5400 with view screen). View the image and "zoom in" (magnify image using camera zoom feature) as necessary to determine whether the focus-target plot number and scale is clearly visible and readable, and whether image clarity and focus are adequate to clearly distinguish features of "captured" crickets. If the image is inadequate for analysis (image is blurry, or did not capture intended grouping, or focus-target not visible or scale is unreadable, etc.), either take additional pictures in this plot, or abandon this plot and move to another location. If the crickets have dispersed, or photographer cannot achieve adequate resolution or focus, abandon the plot and relocate.

8) Take at least one additional picture of this plot. At least two (2) clear and focused pictures should be taken at each plot location. If the first frame captured an adequate image of the plot, repeat the steps to take an additional picture (generally; reposition the focus-target, focus and compose the image, and take the new picture). The new image can essentially duplicate the original frame, or it can be adjusted in any parameter (zoom, camera distance, frame orientation and angle, position of focus-target, specific location of frame/plot in cricket aggregation) so as to potentially improve the resulting image. The additional (new) image should include most of the area included in a previous acceptable, adequate picture of the plot. In no case should a new image include more than about 50% new area, as compared to the other pictures of that plot.

9) Review the additional or new image as in Step 6. Promptly review the new image, and compare it with the previous image(s) for that plot. If the additional image acceptable, the plot is now complete. If not, take and review additional pictures until at least one acceptable image is obtained for the plot. Note: continued illumination and flash-photography of a plot is likely to disturb the crickets, causing them to disperse. If significant dispersal occurs, and an adequate image has not been successfully taken, the photographer must abandon the plot, and move on to another location. If this is done, be sure to take the plot label sticker, and use it for the next plot being photographed. This event should be carefully recorded in the field notes, with clear indication that "plot number #-# was attempted and abandoned, and a new plot location selected to become plot #-#".

10) Before leaving the plot, label the plot location with the plot label sticker. Remove the plot label sticker from the focus-target head and place the sticker number-side-up in a visible location near and beneath the plot. Ideally, the label sticker should be centered beneath the plot as closely as possible. Sticker may be placed on the cave floor, or any other surface (wall-projection, etc.) so as to best show the plot location. This sticker will be the temporary

landmark that enables subsequent project team members to effectively locate the plot for cave air T/RH and plot mapping data collection (see Figure 3a.3.3.).

Figure 3a.3.3. Plot sticker on cave floor at a site.

11) Once a plot has been successfully photographed, the photo-crew will move on to another plot to be sampled within the region, or will move on to the next region, as appropriate. When moving within the region, the photo-crew will usually move to the next nearest plot in the "sampling sequence" of the 8 "best" plots identified for that region. The crew may, however, move across the region to photograph a plot "out-of-sequence", either because of perceived risk of losing that other plot, or because of convenience. (For example, sampling in a toured cave may involve such movement so as to avoid interfering with a tour group moving through the cave region.) Once all plots in both regions have been photographed and locations labeled with plot label stickers, the photo-crew members switch to their next team tasks, as appropriate.

IV. Polar-Coordinate and Distance Mapping of Photographed Plots in a Cave Region

The location of each photographed plot will be mapped using polar-coordinates (compass bearing) and distance (meters) with respect to the fixed **permanent region landmark**. Mapping will be performed by a temporary **mapping-crew** formed by any 2 available project team members. One member will station him/herself at the region landmark to sight on plots, read compass bearings, and read distances off of the tape-measure, while the other member physically goes to plot (label sticker) locations, holds the trail-end of measuring tape, and ensures compass bearing sighting is on target (on the label). For mapping purposes, plot location is usefully approximated by the location of the plot label sticker near to or beneath the actual plot. Distances will be measured in meters to the nearest whole centimeter (1.0 cm). Compass bearings will be determined and recorded to the nearest whole degree. Distance and bearing data will be verbally

relayed to and recorded in the appropriate data fields on the Rite-in-the-Rain field notebook/form (Section VI) by the designated project team field-data recorder (example: “Plot 6 is 11.25 m., 325 degrees”). See Figure 3a.4.1. for an example of a dynamic plot arrangement within cave regions.

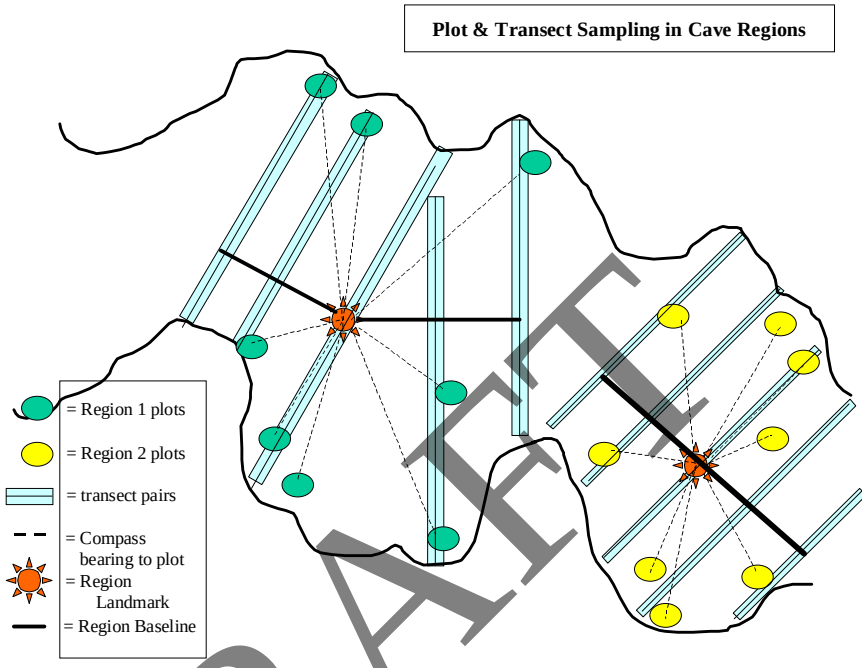


Figure 3a.4.1. Diagram of two cave regions showing locations of dynamic plots, fixed transects, and cave region landmarks. Note that the compass bearing lines to the plots.

Procedures:

Locating the region landmark

Plots will be mapped with respect to the fixed permanent landmark in the region. The landmark will be identified and mapped in the cave region during the mapping phase of the monitoring project prior to initiation of routine sampling events. Region landmarks will be marked on project cave maps, recorded in the project database site locations table (see SOP 6 “Data Management”), and described for ready location during sampling activities in the Cave Cricket Sampling Handbook and associated permanent notes. Region landmarks will be used both for mapping plot locations and for positioning and orienting the virtual transect array during each sampling event. In many cases, region landmarks will not be obviously or permanently marked, in keeping with MACA park policy on limiting impact to and securing cave resources. Locating landmarks may require project team members to perform a map-and-compass exercise in order to find the landmark point within the region. The project team leader and crew members should review all region landmark location information and “finding notes” prior to any sampling event. Appropriate field notes or site descriptions and cave maps, and landmark reference photographs may be obtained and used for locating landmarks, as needed.

1) A designated project team member will locate the region landmark. Use the region-specific site descriptions and notes obtained from the project reference materials and the Cave Cricket Sampling Handbook. Consult with reference photographs, cave maps, and directions, as needed.

2) Once the landmark has been located, position the tripod on top of that point, or at a standardized (and recorded in permanent field notes) location adjacent to that point. If the landmark point is marked by a projecting physical feature (i.e., a man-made structural object, such as a hand-rail post, or a natural cave feature, such as a rock or speleothem), placement of the tripod is not necessary for effective plot mapping, as the landmark feature itself may be used as the sighting point.

Taking (shooting) a bearing from the region landmark to the plot location

Take (shoot) a compass bearing from the region landmark to the plot location represented by the plot-label sticker. Compass bearings (360 degrees of arc) will be taken by sighting with a laser plane device from the landmark to the plot label sticker, and reading/recording the nearest compass or template bearing. Two alternative methods are available for taking the plot compass bearing, depending on whether or not the tripod and laser assembly has been positioned at the region landmark point.

If the Tripod is in Position at the Regional Landmark Point:

The plot compass bearing will be read using the **radial template** attached to the tripod. The radial template provides a 360 degree "bezel" for aiming the laser assembly attached to the tripod pan-head. Note: Use of the radial template requires that the region transect array baseline bearing has been established, either by taking a compass bearing from the landmark, or by using one or more secondary landmarks to lay out the baseline chain.

1) Ensure that the tripod is level by checking the spirit-level mounted on the side of the tripod center-post. Adjust one or more tripod legs, as, necessary, to level the tripod. Setup of the tripod and attached laser assembly is described in SOP 3b ("Transect-Based Sampling").

2) Align the tripod radial template with the **region transect array baseline axis** or bearing. Rotate the template disc on the tripod center post until the template is aligned with and reads the same as the established baseline bearing (example: if the baseline bearing is 321 degrees relative to cave magnetic North, align the template so that its 321 mark is in line with the baseline).

3) Activate the center laser of the laser assembly. The center laser is located directly over the pivot-point or center post of the tripod. Using the center laser will provide the most accurate bearing sighting.

4) Rotate the laser assembly so that the center laser is aimed over the template directly at the plot label, and read the bearing off of the template. Example: the laser is pointed at the plot-label with the plane crossing through the 238 degree mark on the template. This will be the

plot bearing relative to the landmark. Note: the template is "calibrated" for use in each specific region by aligning it with the transect array baseline axis. This axis and bearing is mapped using a magnetic-compass; therefore, the template (and recorded bearing) will refer to the local "North" determined for the region.

If using a hand-held magnetic compass:

Use an adjustable-bezel hand-held magnetic (Suunto Forester or similar compass) to take or shoot a bearing from the landmark to the plot-label sticker. Note: Magnetic compasses may not reliably indicate a "true" magnetic North in a cave, due to mass effects and anomalies present in the rock mass surrounding the cave space. They will, however, typically read a consistent "North" within any given cave region. Magnetic-based compass bearings taken within caves will thus be recorded with reference to the locally-indicated North, but will not be assumed to actually reconcile with "true" North, nor with surface maps.

1) Place or hold a laser plane device on or at the landmark point, activate the laser, and aim it directly at the plot-label sticker.

2) Once you have sighted the laser onto the target (sticker), and align (aim) the compass frame in parallel with the laser plane or beam while looking toward the plot-label. Be careful to hold the compass steady and level while aiming the compass.

3) Once the compass frame is aligned with the laser plane, allow the compass needle to come to rest. At this time, the needle will indicate the cave's magnetic North. Holding the compass frame steady, rotate the compass bezel so that the label "North" is aligned with the compass needle (coincident with the indicated magnetic North), and read the bearing off the bezel at the compass aim line (see SOP 2: "Training", use of the magnetic compass.).

Regardless of which method is used, taking a plot bearing may require approximation of actual bearing, due to obstruction by cave features and geometry which may prevent direct line-of-sight observation of the plot-label from the landmark. If direct sighting is not feasible, the mapping crew will estimate the bearing by sighting as closely as possible to the "real" bearing, and adding or subtracting the estimated number of degrees to cover the discrepancy between what they can aim at and where the target actually lies. Note: error in compass bearings of plus-or-minus 2-3 degrees are generally acceptable in this protocol, as absolute bearing accuracy is not possible, owing to the likelihood that the plot-label sticker could not be placed exactly beneath the "true" center of a sampled plot. Thus, plot-label locations and bearings are proximate. This "fuzzy-ness" in plot location is accounted for in the planned analysis of plot mapping data. The crew member reading or taking the compass bearings will verbally relay data to the designated project team field-data recorder, who will enter the data into the appropriate field notebook/form. It is suggested that the field-data recorder verbally verify the bearing data with the bearing taker prior to writing data onto the form.

Measuring distances from the region landmark to the plot location

The plot mapping crew will measure distances from the region landmark to each plot-label sticker (location) using a 15-meter (or longer) cloth or metallic metric measuring tape in meters to the nearest whole centimeter (1.0 cm).

1) One crew member will be stationed at the landmark to hold the "read or smart-end" of the measuring tape on the landmark point (or on the equipment tripod, if it is in position), while the other crew member pulls the trail or "dumb-end" of the tape out to the sticker location.

2) When the trail-end member reaches and stops at the plot-label sticker and indicates "ready", the landmark-end crew member will read the tape measure and verbally relay this data to the team field-data recorder. (example: Plot 5 is 12.15 meters). Avoid measurement distortions possible from looping tapes over or around cave features, when and wherever possible.

3) After distance is recorded and the landmark-end member indicates "OK", the trail-end person will release the tape and return to the landmark. S/he may retrieve the plot label sticker after distance measurement, if the air parameters have been recorded for the plot, otherwise, the sticker will be left in place so that the AQ sampler may readily locate the plot. The mapping crew will shift focus to the next nearest plot for measurement. When all plots have been located and mapped, the mapping crew members will transition to other tasks, such as performing transect sampling.

V. Measurement of Air Temperature and Relative Humidity at Cave Entrances and at Plots:

Air temperature and relative humidity will be measured outside of sampled caves at the beginning of each sampling event, and in the proximal area of each sampled plot inside caves by a designated project team member (hereafter, the **AQ sampler**). Measurement of T/RH will be accomplished using a hand-held Testo Model 445 T/RH instrument and sensor probe with a standardized 30-second sampling period (see Appendix 3a, operation of the Testo thermohygrometer). Data will be verbally relayed by the AQ sampler to the designated **team field-data recorder**, who will verbally verify the data, and enter it into the appropriate data field of the Rite-in-the-Rain field notebook/form (see Section VI on field data recording and use of field forms). Temperature data will be recorded using the Celsius scale in whole and tenth-degrees (example: 14.2 C). Relative humidity will be recorded in whole and tenth-percent increments (example: 94.4 %).

Procedures:

<u>Air T/RH measurement outside of cave entrances</u>

When the project team first arrives at the cave entrance, T/RH will be measured proximal to the cave entrance using the standard instrument and techniques established for this measurement (see Use of Testo Model 445 ThermoHygrometer). The AQ sampler will perform one T/RH measurement run in a reasonably wind-sheltered location within 10 meters of the cave entrance to provide a sampling-event conditions reference datum for comparison to within-cave

conditions at sampled plots. Measurement and calculation of data means is performed using the steps and procedure defined in Appendix 3a. The AQ sampler will operate the instrument while holding the sensor wand aloft and away from his/her body for 30 seconds, after which, s/he will perform the in-instrument data manipulation steps, and read the calculated T/RH values from the instrument display screen. This data will be verbally relayed to the team field-data recorder, who will enter values into the appropriate fields on the Rite-in the-Rain field notebook page/form.

Air T/RH measurement at sampled plots within caves

Following completion of most or all plot photography within a cave region, the AQ sampler will measure air T/RH at each photographed plot. In general, T/RH measurement should be done in the same (numerical) sequence order as plots are photographed in, to simplify data-recording. The AQ sampler may also simultaneously participate in plot-mapping while s/he is measuring T/RH, if such multi-tasking is efficient and does not confuse or impair either air measurement or mapping activities and related verbal data transfer.

1) The designated AQ sampler will locate photographed plots by locating the plot label stickers left by the photographic crew. Go to the first plot in the sequence. Ask for guidance to the plot location from the photo-crew, if unable to readily locate the sticker.

2) Visually examine the area directly above the plot label sticker to determine the likely area to be sampled. If a group of crickets is present, this determination should favor using that group as the proximate location to be sampled. Otherwise, use the area of substrate located most directly above the sticker as the representative plot to be sampled.

3) The plot will be sampled by placing the instrument probe tip (sensor) at a point roughly 2.0 cm off from the cave surface and centrally within the selected plot area for 30 seconds. Ensure that the probe remains relatively stationary while the instrument records the sampling data, to reduce movement-induced variations in measurement.

4) Once the 30-second sampling run is complete, perform the in-instrument calculation steps to obtain the site data means. Follow the steps and procedures defined in the instrument Operator's Manual (see Appendix 3a, and manual available in MACA project office).

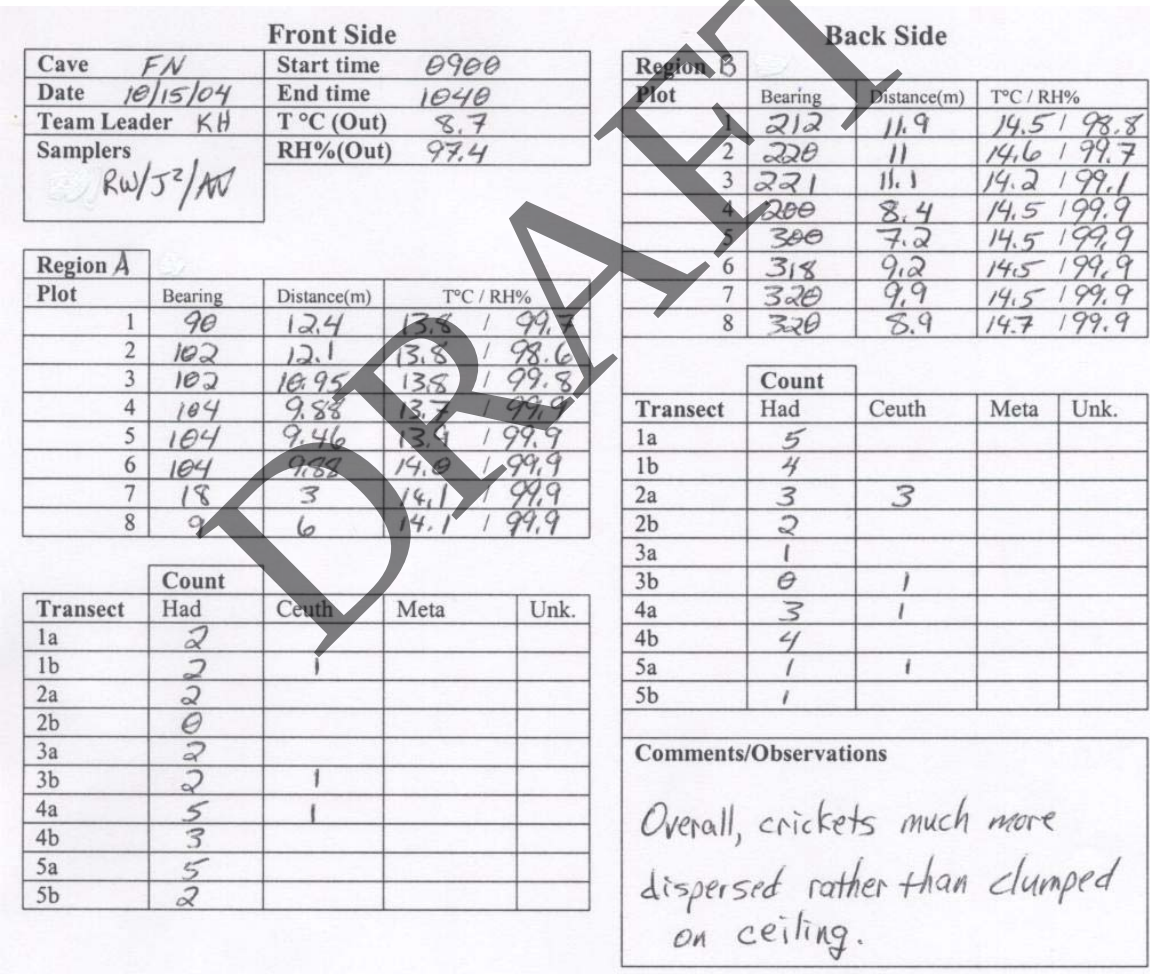
5) Verbally relay the plot data means to the team field-data recorder. The data recorder should confirm or verify the data by verbal feed-back with the AQ sampler before s/he enters it into the field data-notebook/form.

6) Check with other team members to determine whether the plot has been mapped. If so, collect the plot label sticker for later disposal, otherwise, leave the label in place for the plot mapping crew to use.

VI. Filling in the Field Notebook Data Form

Data collected during performance of the field sampling elements of "Transect-Based Sampling" (SOP 3a) and "Plot-Based Sampling" (SOP 3b) will be entered onto a common **Field Data**

Form printed on Rite-in-the-Rain paper (see example, Figure 3a.6.1). The data fields on the form are arranged into the following levels, proceeding from the general to the specific: (1) Sampling event data, (2) Cave data, (3) Region, Plot and Transect ID data, (4) Plot location data, (5) Plot-associated air T/RH data, and (6) Transect count data. One member of each project field team will be designated as the **team field-data recorder** for the sampling event-day. The data recorder will perform verbal verification checks for data quality as data are received from various team members, and will ensure that data are legibly entered into correct fields on the data form. The project team leader will verify all field data at the conclusion of sampling day of the sampling event, and is responsible for ensuring that data forms are secure and safely stored for later processing (see also SOP 5 "Post-Field Sampling" and SOP 6 "Data Management"). Note: The example data form and procedure steps provided in this section apply to both SOP 3a and SOP 3b.



Front Side

Cave	FN	Start time	0900
Date	10/15/04	End time	1040
Team Leader	KH	T °C (Out)	8.7
Samplers	RW/JS/AN	RH%(Out)	97.4

Region A

Plot	Bearing	Distance(m)	T°C / RH%
1	90	12.4	13.8 / 99.7
2	102	12.1	13.8 / 98.6
3	102	10.95	13.8 / 99.8
4	104	9.88	13.7 / 99.9
5	104	9.46	13.9 / 99.9
6	104	9.88	14.0 / 99.9
7	18	3	14.1 / 99.9
8	9	6	14.1 / 99.9

	Count			
Transect	Had	Ceuth	Meta	Unk.
1a	2			
1b	2	1		
2a	2			
2b	0			
3a	2			
3b	2	1		
4a	5	1		
4b	3			
5a	5			
5b	2			

Back Side

Region B

Plot	Bearing	Distance(m)	T°C / RH%
1	212	11.9	14.5 / 98.8
2	220	11	14.6 / 99.7
3	221	11.1	14.2 / 99.1
4	200	8.4	14.5 / 99.9
5	300	7.2	14.5 / 99.9
6	318	9.2	14.5 / 99.9
7	320	9.9	14.5 / 99.9
8	320	8.9	14.7 / 99.9

	Count			
Transect	Had	Ceuth	Meta	Unk.
1a	5			
1b	4			
2a	3	3		
2b	2			
3a	1			
3b	0	1		
4a	3	1		
4b	4			
5a	1	1		
5b	1			

Comments/Observations

Overall, crickets much more dispersed rather than clumped on ceiling.

Figure 3a.6.1. Field Data Form printed on Rite-in-the-Rain paper. This example is marked as a typical form would appear after completion of one sampling event in 2 regions in a cave.

Procedures:

Pre-Departure for Sampling

1) Make sure that you have sufficient blank copies of the data form prior to leaving for sampling on each event-day. Forms should be stored in the covered clipboard for transport and use. Assume that at least two data form sheets will be needed for each cave being sampled. Additional forms are recommended.

In the Field

The designated team field-data recorder should have possession of the data forms and the covered clipboard at all times while in the cave, so that loss or damage to forms (and potential loss of data) can be avoided. See the example data form with entries (Figure 3a.6.1). Starting with arrival at the entrance to the cave to be sampled, the data recorder should enter:

1) Sampling event data

Event Date (mm/dd/yyyy): Record the month (2 digits), day (2 digits) and year (4 digits) in the format shown. Include the forward slash. Example: 06/21/2005.

Team Leader: Enter the team leader's first and last initials. Example: KH

Team Members: Enter the first and last initials of the other crew members. Example: BM, JJ, RW

2) Cave-Level Data

Cave ID: Enter the two-letter code (initials) for the cave being sampled. Example: FN for Frozen Niagara

Start-Time (hhmm): Record the sampling session start time using the 24-hour clock with 4 digits. Fill in all 4 digits. Use only central time zone. Example: 8:45 am will appear as 0845.

End-Time (hhmm): Record the sampling session end time using the 24-hour clock with 4 digits. Fill in all 4 digits. Use only central time zone. Example: 10:20 am will appear as 1020.

Cave Entrance T C (Out): Enter air temperature in degrees and tenths. Example: 19.6

Cave Entrance RH% (Out): Enter the relative humidity. Example: 97.6%

3) Region-Level Data

Region: Enter a 1 for region proximal to entrance, or 2 for region distal into cave

1) Plot-Level Data

Plot: Plot number, 1 to 8, is pre-printed on data form in appropriate lines

Plot Bearing: Enter a bearing in whole degrees. Example: 8, or 43, or 296 degrees

Plot (m): Enter distance from landmark to plot label. Example: 11.25 meters

Plot T C/RH%: Enter the temperature and relative humidity measured at the plot. Use a slash (/) to separate the values. Example: 15.5 / 94.7

2) Transect-Level Data

Transect ID#: Transect ID number is pre-printed in appropriate space on line.

Had (Observed *Hadenoecus* Number): Enter the number of *Hadenoecus* observed in the transect. Example: 2 or 14 or 123

Ceuth (Observed *Ceuthophilus* Number): Enter the number of *Ceuthophilus* observed in the transect. Example: 1 or 14 or 123

Meta (Observed *Meta* Number): Enter the number of *Meta* observed in the transect. Example: 3 or 12

Comments/Observations: Enter a brief comment or observation note, as needed, in the note box provided.

Handling of Data Forms After Completion of the Sampling Event

Once sampling has been completed in the cave, the designated team field data recorder will review the data forms filled out for each region for completeness. S/he will ensure that all entries are in appropriate spaces, are legible, and in the appropriate format. Questions about entries, missing data elements, and notes must be resolved by discussion with the team prior to departing the cave site. At the conclusion of the day's sampling activities, the data recorder will assemble all relevant data forms together, and deliver them to the project team leader. The team leader is responsible for reviewing and verifying all data forms, and for ensuring that forms are stored in a secure location pending data entry (see SOP 5 "Post-Sampling" and SOP 6 "Data Management").

Appendix 3a. Operation of Testo 445 Thermohygrometer

Procedures:

1. Make certain that the measuring instrument is turned off (Figure 4.1).
2. Insert probe cable into Port 2 on the top of the measuring instrument. The arrow on the plug must face the front of the probe (Figure 4.1).
3. Turn the power on.

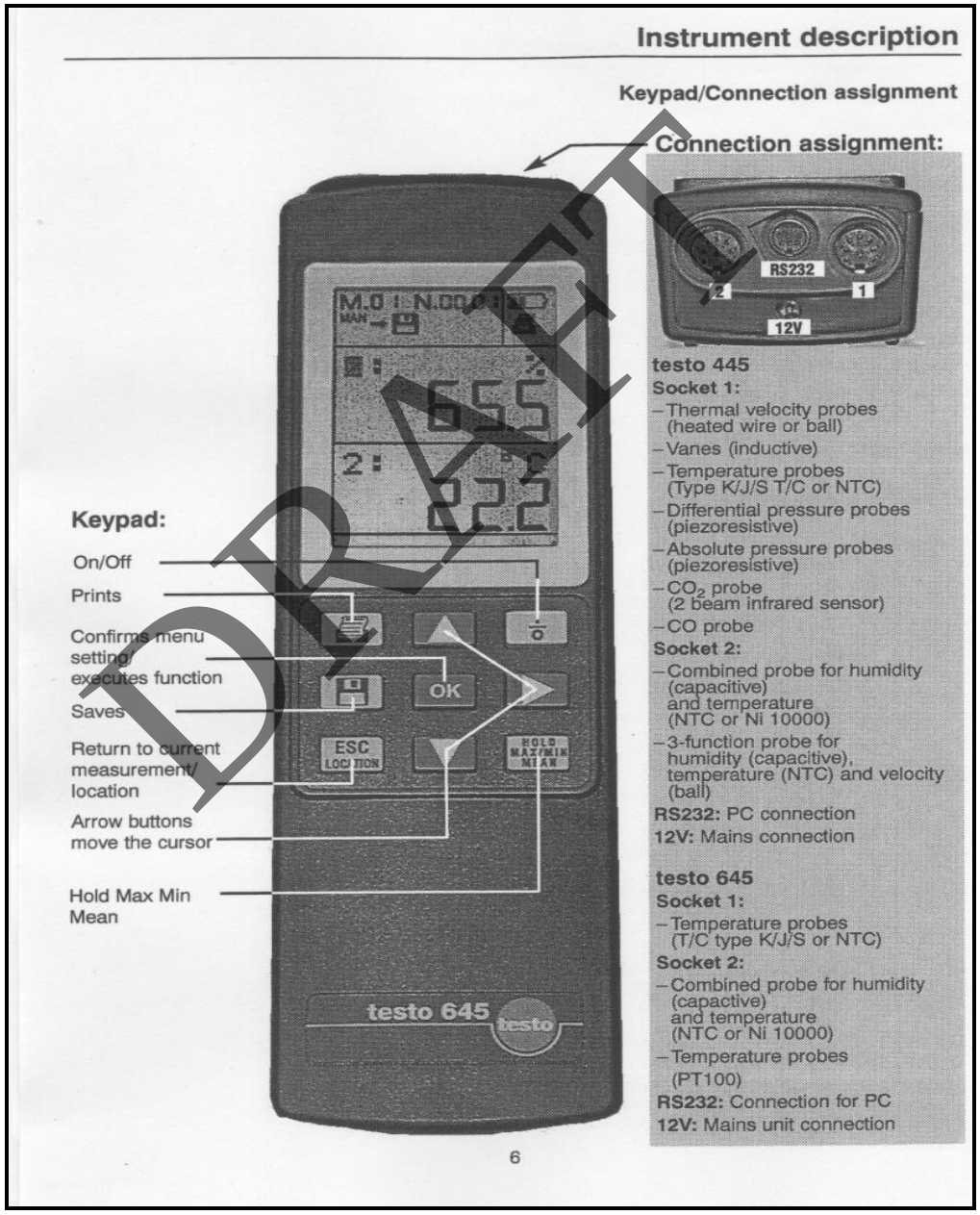


Figure 4.1. Keypad/Connection assignment (left) and temperature probe (inside protective cover) inserted into Port 2 (right).

4. The display on the measuring instrument contains two lines of information. Line 1 will be either relative humidity (%) or dew point (td). Press the up arrow (Figure 4.1) on the keypad repeatedly to toggle between the two measurements. Line 2 will be either the air temperature (^{o}C) or the dew point (td). Press the down arrow on the keypad repeatedly to toggle between the two measurements.

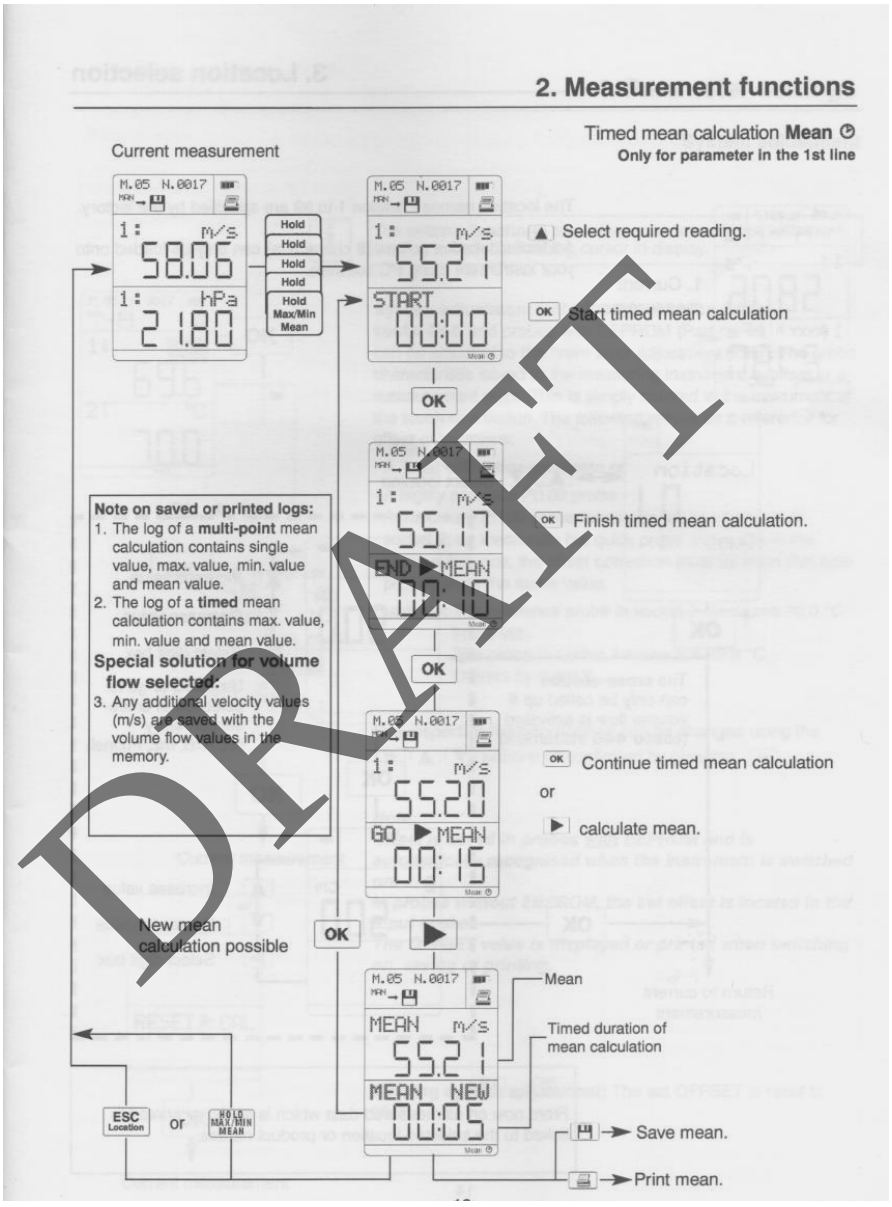


Figure 4.2. Procedure for timed mean calculation.

5. Relative humidity and air temperature must be sampled separately in each cricket plot to get a timed mean (Figure 4.2). To select a parameter, press the up arrow or down arrow on the keypad until the flashing cursor rests over the parameter of choice.
6. Press the "hold/max/min/mean" button four times. The parameter of choice should be on the top line and the lower line should consist of the flashing word "ok" followed by a right arrow and the word "mean."
7. Press the "hold/max/min/mean" button once more and the lower line should consist of the flashing word "start" and "00:00" , where "00:00" is a clock that will track the duration of the sampling event.

8. Hold the tip of the probe as close as possible to the plot without touching the cave ceiling.
9. Press the “ok” button to begin sampling.
10. Sample for 30 seconds.
11. Press the “ok” button to end sampling.
12. Press the right arrow on the keypad to view the parameter’s mean value over the sampled interval.
13. Write the value in the field notebook or call it to the note taker.
14. Press the “hold/max/min/mean” button to return to the measurement instrument’s opening screen.
15. To sample another parameter/location, repeat steps 5 through 14.
16. Turn the power off, detach probe from the T/RH unit, and then detach the probe from the pole.

Cave Cricket Monitoring Protocol for Mammoth Cave National Park
Standard Operating Procedure

Standard Operating Procedure (SOP) # 3b

Field Measures: Transect-Based Sampling

Version 1.0 (December 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure (SOP) gives step-by-step instructions that project team leaders and team members should follow to perform the laser assembly and tripod setup, virtual transect array setup, and transect sampling elements of a cave cricket sampling event at Mammoth Cave National Park (MACA), KY. This SOP describes procedures for: (1) Readying and operation of the tripod and laser assembly, (2) Locating region landmarks for positioning the transect array, (3) Laying out the longitudinal axis baseline of the transect array, (4) Projecting virtual transects from sampling points on the axis baseline, (5) Cricket counting within virtual belt transects, and (6) Filling in the field notebook data form (summarized here and fully-described in SOP 3a "Plot-Based Sampling", Section VI). A checklist summarizing these steps and their proximate order-of-performance is provided in Appendix 2a of SOP 2 ("Pre-Sampling").

Prior to conducting a cave cricket sampling event, all personnel involved should review this SOP (3b), SOP 3a ("Plot-based Sampling"), the related Job Hazard Analyses (JHA's) and follow all safety guidelines (Appendix A, SOP 2, "Pre-Sampling").

General Sampling Approach:

Monitoring of cave cricket populations will involve use of two general sampling methodologies: plot-based photographic recording and sampling for population structure parameters, and estimation of relative abundance and density using transect visual sampling. The field data-collection elements will be accomplished in six 3-day sampling events scheduled to occur at 2-month intervals over the year. Sampling events will occur in the first week of each sampling month (FEB, APR, JUN, AUG, OCT, and DEC). Twelve caves (6 highly-managed and 6 less-managed or natural caves) will be sampled in each event using two 4-person project teams. On each day of a sampling event, each project team will perform all steps described in both SOP 3a ("Plot-based Sampling) and SOP 3b ("Transect-Based Sampling") in 2 regions in each of 2 of the 12 caves. Transect and plot sampling will be performed in tandem by the project team in a

staggered and "choreographed" manner where team members will form temporary "task crews" to implement specific tasks, and dynamically move or switch to other tasks as needed and as members become available through completion of previous work. All field sampling elements are scheduled to be performed between 0700 and 1200 hours of each sampling day. Sampling work within each cave is expected to be completed within approximately 1.5 hours, in most cases; additional time may be needed if a cave presents unusual conditions or difficulties in performing one or more specific sampling tasks. The digital-image analysis and image data entry elements of plot-based sampling, described in SOP 4 ("Digital Image Analysis and Image Data Entry"), will be performed in the MACA project office after all field elements have been completed for the sampling event.

Note that transect-based sampling in a cave region should start only after plot photographing has been completed for that region. Refer to the "Task Scheduling" Section of SOP 2 ("Pre-Sampling") for description of overall order and coordination of sampling tasks among and within caves. The project team leader is responsible for supervising and coordinating the orderly and sequential performance of sampling tasks in the cave to ensure that all tasks are completed in an efficient manner and without undue interference with other co-occurring tasks.

Virtual Transect-Based Cricket Sampling:

The field elements of transect-based cricket sampling (location of region landmarks, laying-out of the transect array longitudinal axis baseline, positioning of the laser tripod, projection of virtual transects, and counting of crickets in transects) will be performed in 2 regions within each cave sampled in each event. Transect-based sampling involves setting up and counting crickets in five pairs of "virtual" (laser-defined) transects positioned in a fixed transect array in each cave region. The transect array is positioned in a region for a sampling event by laying out a longitudinal axis baseline along an established bearing from the fixed permanent region landmark, followed by positioning laser plane projectors to generate pairs of virtual transects at fixed sampling locations along the baseline. Transects are arranged at right-angles to the longitudinal baseline, and extend for varied lengths into the cave space on both sides of the baseline. Sampling is performed by visually counting all cave crickets (*Hadenoecus*) and certain other taxa observed on the cave ceiling in each transect. The transect sampling design consists of one fixed array of 10 transects arranged in 5 conjoined pairs in each cave region, for a total of 20 transects per sampled cave. The transect array and locations, bearings and lengths of transect-pairs will be surveyed and mapped onto the permanent project map for each cave during the initial mapping phase of this protocol. Transect location, bearing and length data are elements of the project database (see Appendix A of SOP 6 "Data Management"). The transect array location within the cave region will base on the same fixed region landmark which is used as the central reference point for polar-coordinate mapping of dynamic plots, as described in SOP 3a ("Plot-Based Sampling").

I. Preparation and Operation of the Tripod and Laser Assembly

Transect sampling will base upon use of "virtual" transects that will be projected onto cave ceilings by a set of three low-power red-light laser devices mounted on a portable camera tripod. The three laser devices are magnetically attached to a rigid mounting frame to form a "laser

assembly" (Figure 3b.1.1. Photograph of laser assembly on tripod). This assembly serves to position and hold the lasers so that they can project three effectively parallel lines or beams, while allowing for small amounts of adjustment to be made in the alignment and positioning of each laser unit. The laser assembly unit is also expressly designed to allow quick, easy, and reliable in-the-field assembly and disassembly to facilitate ease-of-transport into and out of caves, where reducing equipment bulkiness may be an important cave access and safety consideration. The laser assembly is positioned on and attached to the multiple-function "pan-head" of a portable camera tripod using the integral "quick-release" mounting feature of the tripod.

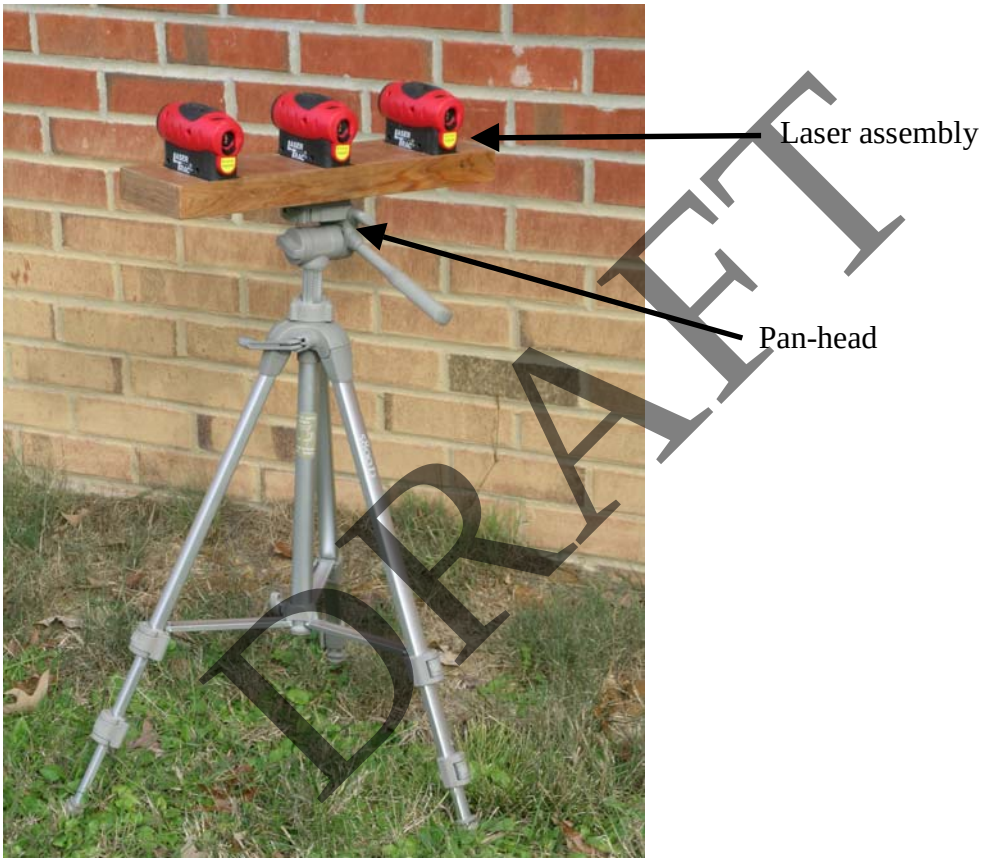


Figure 3b.1.1. Photograph of laser assembly on tripod

The laser unit used for this protocol is the Sear-Craftsman "4-in-1 Level with Laser-Trac, Model No. 320.48251", a commercial "laser plane and level" device used to project leveling lines, such as for leveling a floor or window during house construction (Figure 3b.1.2. Laser Plane). The unit includes an integral spirit-level and a set of detachable magnetic and screw-mount bases for attachment to standard tripods, etc. This unit is a compact, battery-powered, low-power, red-light (650 nm wavelength) diode laser emitter which will project a "plane" or fan of focused red light that covers or spreads out over approximately 100 degrees of arc from the unit face. When used in a cave, the laser plane is visible as a bright, red line "drawn" across the cave substrate in the area in which the laser is aimed. The projected plane is visible across distances of over 40 meters

in a dark cave environment. The laser plane may be rotated up to 90 degrees, allowing users to tilt or position the plane as needed.

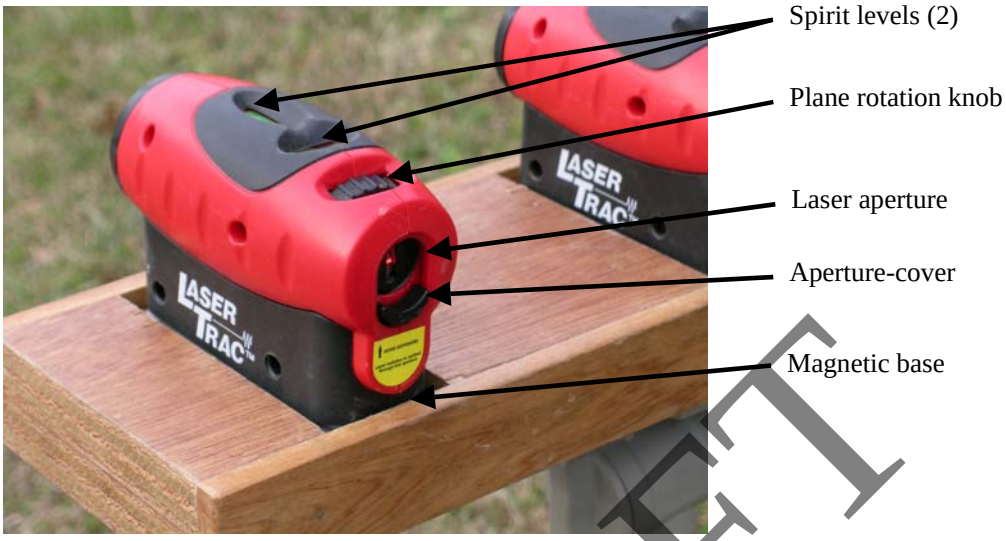


Figure 3b.1.2. Laser Plane

Laser levels are moderately impact-shock and moisture-sensitive, and should be carried and stored in a padded case or field bag when not in actual use. Spare batteries (2 "AA" cells per laser unit) should be carried into the field to provide ready replacement, should need arise. Note: **Laser light can damage your eyes**. Use of laser equipment should be done with due care and attention to safety precautions. **Avoid looking directly at or into the laser emission aperture of the device while the laser is active**. All team members should review the laser device Operator's Manual, paying specific attention to safety information and guidance. Operator's Manual is available for crew inspection in the project office.

The laser assembly is mounted on a compact, light-weight collapsible camera or video tripod for use in the field. Any model of tripod may be used, providing that the tripod has a full-function "pan-head" with a standard size-and-thread (1/4-20 SAE thread) captive mounting screw for attaching a camera or other device to the head platform. Project equipment is the SunPak Model 5800D "PlatinumPlus" medium-duty tripod (Figure 3b.1.3.). This tripod includes a full-function pan-head (providing axial head rotation, platform "pitch" and "yaw" (tilting on the y and z axis in xyz coordinates) and pan-head post extension ability) and an integral spirit-level for leveling the tripod. A key feature is the integral "quick-release" mount and clamp feature that allows for equipment to be easily installed on and removed from the tripod without tools (Figure 3b.1.4.). This tripod model is constructed of anodized Aluminum and plastic- important considerations where exposure to moisture is frequent and corrosion may become an issue, such as in caves.

Figure 3b.1.3. Portable tripod.

Figure 3b.1.4. Tripod “pan-head” with quick-release mount and clamp assembly.

Procedures:

Pre-Departure Setup and Preparation

Perform the following equipment checks and preparation steps within one week before a sampling event, and check for equipment status and readiness again just prior to departure.

1) Check laser units for function by aiming the unit at a safe "target" (away from people and towards a wall or ceiling that will allow adequate viewing of the laser plane) and sliding the power switch (emission aperture cover) "down" to activate the laser (see Figure 3b.1.2. note the aperture cover "switch"). If the laser does not function, turn the power switch back to the "off" position (pull the aperture cover back up and over the laser aperture), and check to determine whether batteries are installed. If batteries are present, remove the old batteries and insert new ones, and repeat the function check. If the laser functions, but appears dim when compared with the other laser units being used by the team, replace the depleted batteries with new batteries. Ensure that four lasers are available (3 for the laser assembly, 1 for hand-held use and service, if needed, as a spare).

2) Put the laser assembly together by placing the **mounting frame** slot-side-up (slots are the seats for the lasers) on a table or other flat surface and inserting the 3 lasers into the slots (Figure 3b.1.5.). Lasers should be positioned so that all three face the same direction. Lasers will magnetically attach to the steel plates located in each slot. Ensure that all lasers can firmly and snugly attach onto the mounting frame. Check the quick-release mounting block located on the under side of the laser assembly frame for tightness and proper alignment with the frame (Figure 3b.1.6.). Align the mounting block with the frame edge and firmly hand-tighten the mounting screw to ensure that the laser assembly will remain firmly attached to the mounting block and stable when clamped to the tripod. Once the laser assembly has been put together and checked, disassemble it for transport by removing the 3 lasers from the frame (See Figure 3b.1.1.).

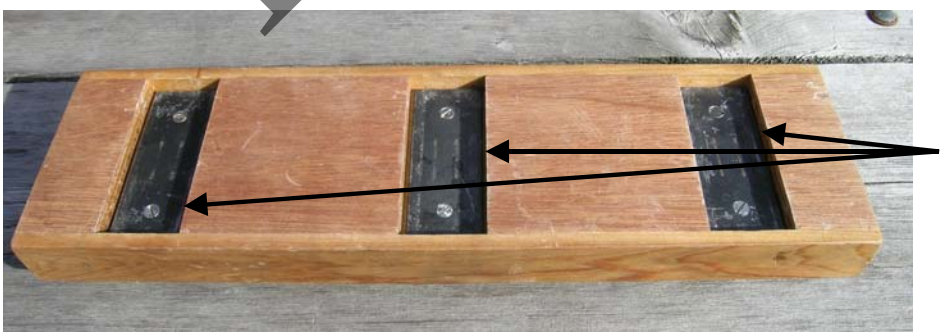


Figure 3b.1.5. Top side of the laser assembly mounting frame showing the 3 laser seats (wells) with steel floor-plates for magnetic attachment of laser units.

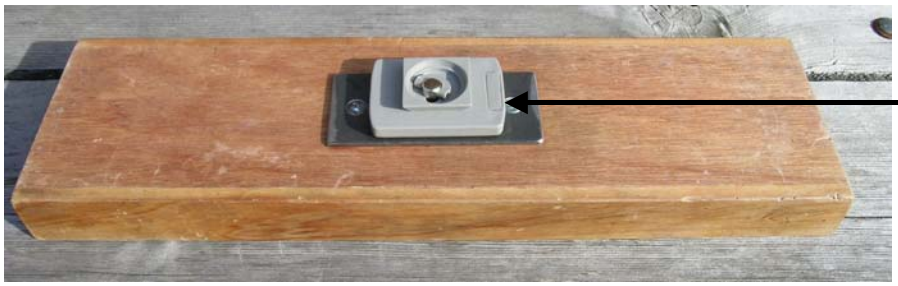


Figure 3b.1.6. Bottom side of the laser assembly mounting frame showing the tripod quick-release mounting block fastened to and aligned on the mounting frame. This quick-release mount allows for easy attachment of the laser assembly in the field without tools.

3) Check the tripod for general condition and all movement functions. Set the tripod up by unfolding and extending the legs. Check the extension, rotation and tilt functions of the pan-head and ensure that all movement-locks function as needed (movement locks operate by twisting or rotating the control handles to clamp down on and immobilize a moving part or component). Ensure that all functional parts appear in good working order and free from distortion or significant damage beyond minor surface wear or abrasion. If legs or pan-head components are damaged and will not reliably function, the tripod must be repaired or replaced. Reliability of the tripod is essential to successful performance of transect-based sampling.

4) Ready equipment for transport to the field by placing the 4 lasers, mounting frame, tripod, measuring tape, flashlight and spare batteries into the field equipment bag.

At Sampling Site

1) Unpack and set up the tripod in the cave region to be sampled. Unfold tripod legs and extend each leg at least one complete section. Leg length will be adjusted at each use-location as needed by shortening or extending one or more sections. Perform a quick check of tripod pan-head functions and half-tighten all movement locks so that pan-head may rotate and tilt with a slight resistance.

2) Put together the laser assembly by attaching the three lasers onto the mounting frame. Ensure that lasers are snugly mounted and that all units face the same direction.

3) Attach the laser assembly to the tripod using the quick-release mounting feature (mounting block on bottom of the laser assembly frame fits into the seat-and-clamp device on the tripod pan-head). Open the clamp on the pan-head with one finger, position the laser assembly onto the pan-head with its mounting block fully-seated into the pan-head clamp well, and snugly press the clamp lever closed to anchor the laser assembly into the pan-head.

4) Check to ascertain that the tripod pan-head and attached laser assembly can be freely rotated and tilted to aim lasers as desired. The tripod and laser assembly are now ready for placement and use at any sampling point in the cave region.

5) Check the position of the tripod **radial template** located just below the tripod pan-head. This template is incremented in 360 degrees of arc around its circumference, and can be used to emulate a magnetic compass bezel when sighting or taking a bearing. The template disc should be stable and level around the tripod center post.

II. Locating Region Landmarks for Positioning the Transect Array

Positioning of the transect array is based upon the location of the fixed, permanent **landmark** in the cave region. The region landmark is used both to position the longitudinal axis baseline of the "fixed" transect array, and to provide the reference point for polar-coordinate mapping of dynamic cricket plots. Permanent landmarks will be identified in each cave region during the initial mapping phase of this protocol. In general, region landmarks will be marked by distinct physical features or points more-or-less centrally-located within the region space. Features may include both natural (i.e., rocks, speleothems) and anthropogenic structures (hand-rails, etc.) that are readily discernable to project team members performing sampling work in the cave. Region landmarks will be marked on project cave maps and described in permanent field notes for each cave, as detailed in the "Cave Cricket Sampling Handbook" (see Appendix D, under development). All project team leaders and members should review the Handbook and project cave maps for all caves that the team will sample during the sampling event. It should be expected that at least one member of each project team will have personal experience and familiarity with the region landmarks of the caves his/her team will sample. It is recommended that the team leader ensure that s/he knows where region landmarks are and how to reliably locate them prior to performing a sampling event, to prevent possible confusion that can occur when uncertain as to where a landmark lies. The project team leader will be responsible for ensuring the correct location and identification of region landmarks during sampling.

Procedures:

Pre-Departure for Sampling

1) Review the appropriate project cave maps and the region landmark description and location notes presented in the Cave Cricket Sampling Handbook to ascertain where in the cave you will find the region landmarks. Be sure to examine the site reference photographs if unsure as to the appearance of the landmark feature or structure.

2) Obtain copies of the Cave Cricket Sampling Handbook, relevant project cave maps and relevant landmark reference photographs for use in the field, as needed. These materials will be available in the MACA project office. Generally, these materials should be in the possession of the project team leader during the sampling event.

At Sampling Site

In general, the project team leader or other knowledgeable team member will move into the cave region and locate the landmark when the photo-crew are nearing completion of plot photography. Locations of region landmarks (and the specific "clues" and routine for finding them) are specific to the cave and region. Finding and recognizing the region landmark points are more a

matter of experience and practice than an exact process. When in doubt as to the location of a landmark, refer to the Cave Cricket Sampling Handbook and the reference photographs, which will show, with an indicator label, the specific structure or feature comprising the landmark. Once the region landmark has been located, mark it with a flashlight or the spare laser unit, or place the assembled tripod on the landmark. After the landmark has been identified, project team members may proceed to perform plot-mapping tasks and lay out the transect array baseline.

III. Laying Out the Longitudinal Axis and Baseline Chain for the Virtual Transect Array

The virtual transect array is based upon use of a longitudinal axis baseline, which provides the locating positions for each of the five pairs of transects to be sampled in the array. The baseline is nominally a straight 8-meter line that crosses through or over the region landmark and points in a fixed bearing or direction through the cave region. The five pairs of transects are, in most cases, located at 2-meter intervals along the baseline (in some regions, extra spacing between some transect pairs is used to accommodate the geometry of the cave region and baseline). The exact position, length, and bearing of the baseline are dependent on the physical form and features of the cave region. For example, in Frozen Niagara Region 1, the transect baseline is a "dog-leg" that extends 8 meters on one side of the region landmark, and 4 meters, at about 80 degrees off of the longer leg, on the other side of the landmark (thus appearing like an "L", as viewed from above). The Region 2 baseline, in contrast, is a "typical" 8-meter straight line centered on, and extending 4 m to either side of, its region landmark. Region 1 is essentially a narrow, long corridor or hall with a distinct and sharp bend in it, while Region 2 is a wider "room". Both baselines are arranged along fixed compass bearings with respect to their region landmarks. See Figure 3b.3.1.

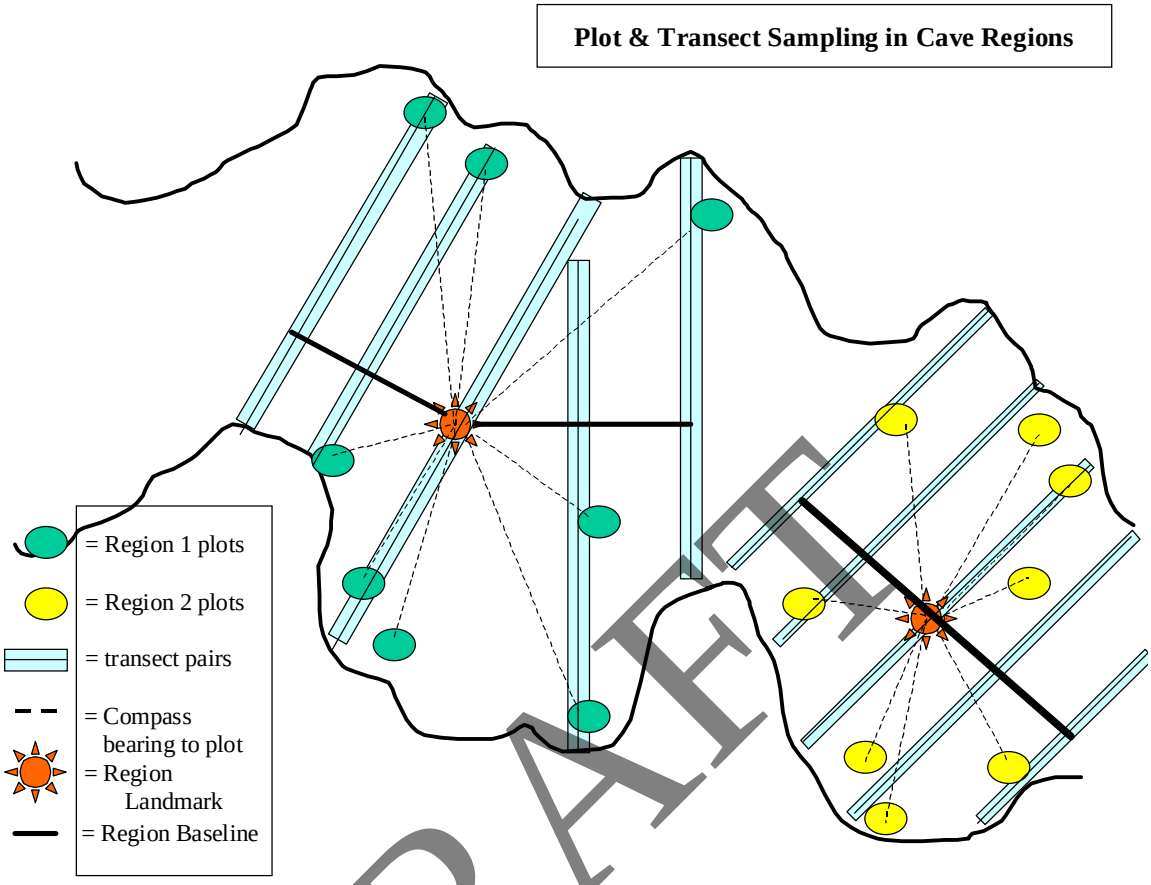


Figure 3b.3.1. Diagram showing the lay-out of dynamic plot and transect sampling in a cave. Note the region landmarks, the transect array baselines, and the virtual transect pairs.

Region-specific **baseline "chains"** are used to simplify laying-out the transect array. Each "chain" is made from a section of white, braided ¼-inch polypropylene cord cut to the appropriate length for a region's baseline (8m or longer). The ends of the cord are heat-fused to prevent un-raveling during use. The landmark cross-point and five transect-pair locations (**sampling points**) are marked on the chain using colored plastic tape rings (black for the landmark point, red for all transect-pair sampling points other than the landmark point. The landmark point can also be used as a sampling point). Use of the baseline chain simplifies transect array setup by providing already-spaced and marked sampling locations without need to re-measure each time the array is set up.

Procedures:

Pre-Departure for Sampling

1) Obtain the array baseline chains for the four regions of the two caves to be sampled on the event-day. Inspect each chain for worn or damaged or obscured marking rings, and repair as necessary. Ensure that chain cave and region identity labels are legible. Note: baseline chains

should be stored in a designated project space, area or office between sampling events (see SOP 5 "Post-Sampling").

2) Check the Cave Cricket Sampling Handbook for the compass bearing(s) and lay-out particulars for each baseline and array. Compass bearings may be replaced in practice by use of secondary physical landmarks used to orient the baseline in the cave region. If so, these secondary landmarks will be identified by cave and region in the permanent field notes section of the Handbook, and should be marked on the appropriate project cave maps. Note: Baselines may not be symmetrical in layout across a region landmark. Ensure that the specifics of layout are understood and noted for each baseline the team will use. The project team leader or a designated team member should ensure that this information is logged into the field notebook prior to starting on a sampling event.

3) Pack labeled baseline chains with the laser assembly and tripod in the project team's field equipment bag for transport to sampling sites.

At Sampling Site

1) Physically locate the region landmark (see Section II above) and any secondary landmarks, if applicable, in the region to be sampled. Use the region-specific notes obtained from the Cave Cricket Sampling Handbook. Check the field notebook for notes on baseline arrangement particulars (i.e., direction bearing, asymmetry across landmark, dog-legs, etc.).

2) Center or locate the appropriate baseline chain on the landmark. Unroll the chain, locate the **black landmark-cross-point marker ring** on the chain, and position this marker on the landmark. Arrange the chain so that the appropriate portions are situated on either side of the landmark toward the proximate directions of the baseline axis bearing. If secondary landmarks (other features that you can "aim" the baseline at) are being used, align the baseline chain sections in the direction of these secondary landmark(s).

3) If not using secondary landmarks, establish the direction bearing(s) for laying the baseline, including any bends or "dog-legs", by either taking (shooting) a bearing from the region landmark with a hand-held magnetic compass, or by using the radial template attached to the laser equipment tripod. (Use of the compass and tripod radial template is described in Section IV of SOP 3a "Plot-Based Sampling").

4) Fully extend the baseline chain along the established axis bearing, being careful to avoid pulling the chain landmark marker off of the landmark point. Lay the fully extended chain down, ensuring that there are no knots, coils or large bends in the cord that will lead to wrongly positioning transect points. Once this is done, the baseline is ready to be used for transect sampling.

IV. Projecting Virtual Transects From Sampling-Points on the Axis Baseline

Transect sampling is performed by counting crickets observed in pairs of virtual transects projected across the cave ceiling using laser plane devices mounted in a laser assembly. Each

transect is a 15-cm-wide belt of varied length (length is determined by the available ceiling area to be sampled across the cave space at that particular sampling point). The transects are "conjoined" (share a common mid-line) into pairs that are marked by the three parallel laser planes spaced 15 cm apart on the cave ceiling. Transect-pairs are located at the sampling points spaced along the array baseline chain. Each transect-pair is arranged so that it crosses the baseline at right-angles (90 degrees), with the common, or mid-line, of the transect pair centered directly over the **transect marker point** on the baseline chain. Transects remain "fixed" in location over time by positioning the baseline and associated transects in the same locations and at the same angles and bearings in each sampling event. Transect lengths provide, in multiplication by the fixed transect width of 15 cm, the area data needed to estimate cricket density in the transect and region. Transects will be mapped and measured for length during the initial cave mapping phase of the protocol. Transect length and location data will be entered as elements in the locations tables in the project database (see SOP 6 "Data Management", Appendix A). Establishing (setting up) a virtual transect-pair is performed by the transect crew directly before counting of crickets.

Procedures:

1) Position and set up the tripod at the **sampling point marker** (any red ring on the baseline chain) to be sampled from. Ensure that the tripod is stable and level. The transect-crew may either place the tripod directly on and centered over the transect marker ring, or may place it in a near location to one side of the baseline and at a right-angle to the transect marker ring. (This arrangement would appear as a "right-triangle" as viewed from above, with the right-angle being the join between the baseline and the line out to the tripod.) Be sure that the center-post of the tripod is properly positioned with respect to the marker, to ensure that the transect-pair is projected into the correct "fixed" sampling location. Level the tripod by adjusting the length of one or more legs while using the spirit-level.

2) Attach the laser assembly to the tripod using the quick-release clamp, if the assembly is not already installed.

3) Aim the laser assembly so that it points at a right-angle across the baseline axis. Rotate and tilt the laser assembly ("pitch", front-to-back tilt) so that the laser planes project up and across the ceiling to be sampled. Ensure that the projected virtual transects are perpendicular to the baseline axis by visually comparing the lines. Using the available extra laser unit to trace or parallel the baseline chain with a laser line across the cave ceiling will make this visual comparison easier.

4) Operate the laser assembly while the transect is being counted (see Section V. below) so that the entire length of the transect area can be sequentially marked. As the laser planes are limited in the arc of ceiling they can mark at any one time, the **laser operator** may need to "extend" or shift the transect lines as samplers move along and count organisms. Tilting the laser assembly through its full travel will cause the transect lines to appear to move longitudinally across the cave ceiling and extend along the span being observed. The laser operator should pay close attention that the laser assembly remains stable on the tripod pan-head during this rotation, and that the three laser planes remain parallel to each other. Note:

Caution! Both the transect observer and the tripod operator should carefully avoid looking into the lasers while these movements, and transect observing, are in progress.

V. Counting Crickets Within Virtual Transects

Counting of organisms in the transect is performed by the designated **observer.** The observer searches the projected transect-pair and counts and mentally tallies all *Hadenoecus* and *Ceuthophilus* individuals and spiders (genus *Meta*) encountered in each transect. Generally, sampling in a transect-pair may proceed from either end of the transect, at the discretion of the observer. Transect-pairs may be sampled within a region in numerical order (i.e., transect pair 1, followed by 2, etc.), or reverse order (counting down from pair 5). Transect data will be verbally transferred as counts-by-organism-by-transect number (example: "8 Had, 2 Ceu, 0 Meta for transect 1a") by the transect observer to the designated team field-data recorder, who will verbally verify these data and enter them into the appropriate fields on the field-data notebook/form.

Note: Observers should be confident that they can adequately distinguish between and recognize the taxa being sampled on sight. Prospective observers need to practice transect observation techniques prior to performing transect sampling during sampling events. See SOP 1 "Training Observers".

Procedures:

1) Select the end of the transect-pair that sampling will start from. The observer should approach or position him/herself so that the starting point area is fully visible, so that all crickets and other organisms may be observed and counted. The observer should be careful to check for loose substrates and other footing hazards along the transect path to be traveled before searching the transect, as one's eyes and attention will be directed toward the cave ceiling while sampling.

2) Using a low-powered headlamp, helmet lamp, or flashlight (an LED lamp is recommended), simultaneously scan both transects in the pair and mentally note or tally all crickets and spiders observed in each transect. Be sure to carefully note which transect organisms are seen in. Keeping this dual tally for two transects is relatively easy to do, but should be practiced before any sampling event to ensure confidence in observation and tracking of organisms. Note: Crickets and other organisms may be observed "on-the-line" at either edge of either transect. Two general "inclusion" rules are used to determine if and where an individual should be recorded as being found:

   - (1) If observed at the outer edge of a transect, and any clearly-visible part of the organism (limb or body region) is clearly **inside** the transect outer boundary line, the organism is counted as being "in" the transect.

   - (2) If observed to be straddling the transect-pair mid-line: The organism is counted as being "in" the transect in which the larger portion of its **body** lies.

Note: Strictly avoid "waiting" for moving organisms to "decide" whether they are "in" or "out" of a transect. The observer must expeditiously move along the transect, and must make the inclusion decision promptly when the moving individual is encountered during the sampling process.

3) As the observer moves along the length of the transect, the laser operator adjusts the tilt of the laser assembly to ensure that the area the observer is viewing is clearly delineated by the laser planes.

4) After reaching the end of the transect, mentally compose the data for verbal relay to the designated team field-data recorder. Verbally deliver the data. The data recorder should verbally verify the data received before entering it into the field notebook/form.

5) The transect-crew picks up the laser tripod and moves to the next transect marker and repeats the sampling process (Section IV, Steps 1 – 3, and Section V, Steps 1 – 5). When all transects for both regions are done, the crew members transfer to other tasks in the sampling event, as needed.

VI. Filling in the Field Notebook Data Form

Data collected during performance of the field sampling elements of "Transect-Based Sampling" (SOP 3a) and "Plot-Based Sampling" (SOP 3b) will be entered onto a common **Field Data Form** printed on Rite-in-the-Rain paper**. The data form, fields, and examples of entered data are provided in Section VI of SOP 3a "Plot-Based Sampling".** Follow the procedures for entering data into data forms given in Section VI of SOP 3a. The team data recorder will perform verbal verification checks for data quality as data are received from observers, and will ensure that data are legibly entered into correct fields on the data form. The project team leader will verify all field data at the conclusion of sampling day, and is responsible for ensuring that data forms are secure and safely stored for later processing (see also SOP 5 "Post-Sampling" and SOP 6 "Data Management").

Pre-Departure for Sampling

1) Make sure that you have sufficient blank copies of the data form prior to leaving for sampling on each event-day. Forms should be stored in the covered clipboard for transport and use. Assume that at least two data form sheets will be needed for each cave being sampled. Carrying additional forms is recommended.

Handling of Data Forms After Completion of the Sampling Event

Once sampling has been completed in the cave, the designated team field data recorder will review the data forms filled out for each region for completeness. S/he will ensure that all entries are in appropriate spaces, are legible, and in the appropriate format. Questions about entries, missing data elements, and notes must be resolved by discussion with the team prior to departing the cave site. At the conclusion of the day's sampling activities, the data recorder will assemble

all relevant data forms together, and deliver them to the project team leader. The team leader is responsible for reviewing and verifying all data forms, and for ensuring that forms are stored in a secure location pending data entry (see SOP 5 “Post-Sampling” and SOP 6 “Data Management”).

Cave Cricket Monitoring Protocol for Mammoth Cave National Park
Standard Operating Procedure

Standard Operating Procedure (SOP) # 4

Field Measures: Digital-Image Analysis and Image Data Entry

Version 1.0 (December 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure (SOP) gives step-by-step instructions that project team image analysis personnel should follow to perform the digital plot image processing and analysis and image data entry elements of a cave cricket sampling event at Mammoth Cave National Park (MACA), KY. This SOP describes procedures for: (1) Down-loading, sorting and labeling of plot image files, (2) Performing image analysis to collection of data on crickets, (3) Recording individual data on the image analysis data form, and (4) Post-analysis image archiving and assembly of data forms. A checklist summarizing these steps and their proximate order-of-performance is provided in Appendix B of SOP 2 “Pre-Sampling”.

Prior to performing plot image analysis for a cave cricket sampling event, all personnel involved in image analysis should review this SOP (4), SOP 3a (“Plot-based Sampling”), the Cave Cricket Sampling Handbook (in development), SOP 1 “Training Observers”, SOP 5 “Post-Sampling”, and SOP 6 “Data Management”. Image analysts should participate in at least one cave sampling session (sample at least one cave) as part of their training to perform the tasks described herein. Personnel who may serve as image analysts include CUPN and MACA Prototype Program staff, student workers, and interns. Image analysis tasks will be performed by teams under the supervision of the project team leader, who is responsible for ensuring that all image analysis and data entry is performed in a timely manner after completion of a sampling event.

General Sampling Approach:

Monitoring of cave cricket populations will involve use of two general sampling methodologies: plot-based photographic recording and sampling for population structure parameters, and estimation of relative abundance and density using transect sampling. The field data-collection elements of these methodologies will be accomplished in sampling events performed by 4-person project field teams. The digital-image analysis and image data entry elements of plot-based cricket sampling, as described in this SOP (4), will be performed in the project offices after

completion of all field sampling elements described in SOP 3a and 3b. See the protocol Narrative for a complete description of the sampling design and process.

I. Down-Loading, Sorting and Labeling of Plot Image Files in Camera Memory

The key end-product of performing cricket plot photography in the 2 regions of a sampled cave is a set of digital images that record groups of crickets present in sampled plots. Each of the 16 plots photographed in a cave will be recorded in one or more color images taken per plot. Sampling a cave will yield a set of approximately 35 to 50 images. Each image is stored as a "jpg" image file (ca 1.0 MB) in the camera flash-card memory. Images are stored in the sequence taken, and are automatically labeled with date and time-taken by the camera. At the conclusion of a sampling event day, the image files will be downloaded from the camera flash-card memory onto a designated project office computer for image sorting, labeling, and archiving onto CD memory. Downloading of image files from the Nikon Model 4500 and 5400 digital cameras is performed by transferring images using the image-downloading software (NikonView vers. 6.0) provided by the camera manufacturer. The downloaded images may be easily stored for sorting and labeling on the PC by saving them within picture file folders and placing these folders into any storage directory the user selects (typically, the "My Documents" directory). The stored image files are easily sorted by opening the file folder in NikonView, or in any of several common photo-editor applications, and viewing each image to evaluate whether the image should be kept for image analysis. Unsuitable or surplus images can be easily deleted from the file folder. The saved images can then be labeled for processing and archiving using either MS Windows or NikonView, as desired, to rename each image file with a unique code label. Labeled images are then saved into folders labeled to represent the cave, region and date of the sampling event. These labeled folders will be transferred to the image analysis team for processing. These folders and images contained therein will also be copied onto CD memory and archived. Downloading, sorting, labeling, and storing of images onto CD memory will be performed by a designated project team member (typically, a member of the photo-crew who took the pictures) following completion of sampling for the event. These tasks will take approximately 20 – 30 minutes per cave image set. Image downloading and processing should occur promptly after completion of sampling, as image analysis and data entry are fairly labor-intensive and lengthy tasks that must be initiated as quickly as possible.

Procedures:

<u>Prior to Downloading Images From the Camera</u>

1) Install the NikonView photo-processing utility software onto the PC that will be used for receiving or downloading images from the camera. Software installation on NPS computers is controlled by and performed by designated authorized personnel. Request assistance from MACA IT staff to perform this installation. NikonView will remain resident once installed, and so this is a "one-time" preparatory step for any given computer. Note: Several versions of NikonView may be available. Each Nikon camera model comes with multiple versions. All versions are back-compatible, so version # is probably not critical, at this time.

2) Ensure that the designated computer has an available "USB" port. The image transfer will occur over a data cable link between the PC and the camera. This cable is a USB connector. NikonView will "handle" all necessary setup to be performed by the host computer (PC) for this transfer.

3) Ensure that the designated computer is either a) connected to the MACA LAN, to provide for image transfer via the LAN to other computer(s) for image analysis, and/or b) has a CD-R/W drive that will support creating CD memory discs for image storage, transfer and archiving.

Download the Image Files From the Camera to the PC

The steps listed below are generalized (no screens, "buttons" or commands are provided): the user should refer to and use all appropriate procedures as determined for his/her computer. For NikonView and Nikon camera procedure step details, consult the Nikon Operator's Manual available in the MACA project office.

1) Turn on the designated computer and perform appropriate log-in routine. Proceed through all user steps necessary to arrive at the active "desktop". NikonView will be represented on the desktop display screen with a Nikon icon, and will be identified in the Programs Directory.

2) Open the NikonView utility. Typically, this is done by "double-clicking" on the desktop icon, or on the program directory line labeled "NikonView vers. 5.0". While NikonView opens and sets up its screen, unpack and ready your camera for image transfer.

3) To ready the camera for image transfer, first check that the camera has a charged battery, and that the memory card with the images on it is properly installed in the camera. Perform a function check by turning on the camera and running through the steps to view a recorded image (steps are detailed in SOP 3a "Plot-Based Sampling"). If the camera operates normally, and images can be viewed on the camera display screen, the camera can be used to transfer images.

4) Check the transfer status of the image files on the camera. Normally, images are stored on the flash-card in an "un-protected" status, meaning that they can be readily transferred without further in-camera processing. In order to change this normal status to some other, such as to "protected" (and thus possibly not transferable), the camera operator MUST have entered into the image menu and changed this status. Only check image status if you have done this change.

5) To hook the camera up to the computer, first ensure that the camera is turned "off". Install or attach the Nikon USB transfer cable to the camera data-export port. Connect the USB plug end of the cable to an available USB port on your computer. The camera is now physically attached to the computer. When you power up the camera, it will communicate with the computer, and "log-in" to NikonView for image transfer.

6) Check the computer to see whether NikonView is loaded and ready to receive images. You will see a NikonView screen indicating this status.

7) Turn the camera on. After a few seconds, the camera will setup and will communicate with NikonView. You will see a USB icon illuminate on the lower toolbar (signifying that the device is in operation). NikonView will acknowledge connection with the camera by presenting a small overlay screen which provides "buttons" for initiating file transfer.

8) Transfer the image files by using the "transfer all images" button on the overlay menu screen. Transfer will start within a few seconds. Transfer will take a few seconds to 2 – 3 minutes, depending on how many images are stored on the card (up to about 240 on a full 256 MB flash card).

9) NikonView will indicate when all images have been transferred. After this occurs, you can disconnect the camera from the computer. Use appropriate procedure to detach a USB device from the computer. Once the disconnect is "OK" with the computer (a few seconds), detach the camera from the USB cable and turn the camera off. Transfer of mages to NikonView is now complete.

10) At some later time**, after images have been processed and successfully archived,** use the camera image control menu and commands to empty the flash-card memory (delete current images) and prepare the camera and card for the next sampling event. Only delete the images after you are certain that you have successfully downloaded and successfully copied them onto CD memory for archiving.

The current set of images for the cave are now stored in a "folder", labeled with a unique **folder ID number**, in the NikonView sub-directory in the host computer. The images are stored as "jpg" files with annotation for date, time, and exposure parameters, as provided by the camera during image recording. Images are stored and listed in this folder in the order in which they were taken in the cave. This is important, as the next step is to view these images on the computer and sort them for "keeping and using, or disposal", and sorting can occur, at the discretion of the processing individual, either before or after images are properly labeled for image analysis and archiving.

Sort and Label the Images

Sorting of images is a process where the photographer will scan all of the images in the cave folder and decide which should be discarded and which should be kept for later analysis and permanent archiving. This sorting is essentially the opportunity to "caste out" those images that you don't feel any need to keep. Sorting is performed by sequentially opening and viewing the image files, inspecting them for clarity and content, and deleting those that do not meet the **general selection rule**. The rule used is: "Keep all images that appear to be **adequate for analysis** : discard any image that is **too blurry** to accurately analyze, or that does not have any crickets in it (**"no crickets"**), or that does not include the plot-label sticker that identifies the plot photographed (**"no plot-label")**". Perform sorting in a conservative manner- keep any images that appear to be useful.

Sorting is generally performed in conjunction with **image labeling**, as it is most convenient to change the name of the image file at the time you have opened it for inspection. Labeling and image is accomplished by changing the image file name from **the image ID number** automatically assigned by the camera to the appropriate **image ID code**. The image ID code is the defined-content-and-format label that will be used to uniquely identify this image as to where and when it was taken (what cave, region, plot, sequence number in plot, and date) (Example: FN 100304 r1p2a, for "Frozen Niagara cave, Oct 03 2004, region 1, plot 2, first image"). Changing the image file name can be easily performed using either the MS-Windows file commands, or those imbedded in NikonView, at the user's discretion. The sorted and labeled images will remain in the original "folder" they were downloaded into. After sorting and labeling of images is complete, label the cave folder with a cave code and date (Example, FN 100304 cricket pix, for "Frozen Niagara cave, Oct 03 2004 cricket plot pictures"). This label will be the permanent image folder label under which this set of images will be stored and archived on the CD disc. Once the folder and images are labeled, save the folder back into the "My Documents: Pictures" sub-directory on the computer preparatory to image file transfer for analysis and archiving onto CD memory.

1) Open the "cave image folder" with the current set of plot images in it, using either the MS-Windows-supported imaging utility provided on the host computer, or NikonView. The folder is listed in the NikonView folder pull-down list or the sub-directory by its assigned folder ID number.

2) The images are displayed in sequential order either as numbered **image icons** (image ID number from the camera) (MS-Windows imaging utility or "my pictures" files-display), or as **"Thumb-nail" images** with ID number labels, if using NikonView. Select the first image in the displayed list or series. This image is the first image taken in the cave on this sampling event. If it is a plot image (it could be anything else that was photographed using this camera and card!), open the image and examine it to determine whether it is a plot image. (If the image is not a plot image, discard or delete it from this folder now.) Note: These non-plot images are still stored on the camera memory card, and may be retrieved and stored elsewhere at the user's discretion. They should NOT be stored in the cave image folder that will be labeled for plot images for analysis and archiving.

3) Scan the opened plot image and determine whether it should be kept, or should be discarded. If the image is judged to be inadequate, delete the image file using the appropriate commands.

4) Label the kept plot image with its appropriate **image ID code** (example: FN 100304 r1p2a) using the file-rename commands in MS-Windows or in NikonView. Note: Plot images appear in the sequence in which they were taken, and adequate plot images have imbedded a visible plot-label. Determine the unique ID code based upon this information. If you **do not purposefully delete** this image, it will automatically "save" and be kept. Move to the next image and repeat steps 2-4 until all images in the folder have been sorted and labeled.

5) Label the "cave image folder" with its appropriate cave code and date (example: FN 100304 cricket pix) using the file-rename commands in MS-Windows or in NikonView.

6) Save the labeled folder into the desired directory or location on the host PC using the appropriate MS-Windows or NikonView file commands. The folder should be saved in a location where it is safe and can be readily retrieved for transfer to either another computer for image analysis or to a CD-writing utility (CD "burner"). If several cave image folders are being processed in this session, move on to the next folder and repeat steps 1-6 until all folders are labeled and saved.

Save Images to a CD for Archiving, and Transfer (if Needed) Images for Image Analysis

All labeled plot images will be saved onto CD memory media for archiving in the MACA project offices and/or by the MACA curatorial staff. (Image files will also be archived via the project database and by the program data management team and system. See SOP 6 "Data Management" and the CUPN-MACA Monitoring Program Data Management Plan for procedures and rules.) Once all image files and folders for the sampling event have been labeled and saved on the host PC, transfer them to CD memory media using the available CD "burner" utility. Each cave folder will contain, on average, approximately 50 images, and will need about 50-60 MB of storage space. A typical CD will hold up to about 700 MB, or 10-12 cave folders. Multiple cave folders may be stored on one CD, or they may be packaged separately, as determined by the project leader and the MACA program coordinator. Image files in folders are also stored on the host PC pending possible transfer via the MACA LAN system to another computer for image analysis, (analysis can be performed using any PC that hosts the appropriate imaging application). The general steps below are used to save files onto the CD memory, and transfer files for analysis via the MACA LAN.

1) Open the CD writer/creator (CD "burner") utility on the host PC on which the cave folders are stored. Follow the commands to start creation of a "data" or "image" CD.

2) The "create" process will require you to select the files(s) and/or folder(s) that will be saved onto this CD. The CD "burner" will provide a route to access the files directories on the PC and select files for transfer or copying to the CD space. Select the folder(s) to be copied to the CD.

3) Once the appropriate folder(s) have been selected, follow the commands for copying them onto a CD. A number of quick command steps are used to initiate and perform this data transfer. The transfer process should take several seconds to a few minutes, depending on how many folders and images are to be transferred.

4) Once transfer is complete, the "burner" will indicate this, and will query as to what you want to do (label CD, add notes, etc.). "Close" and save the CD using the appropriate commands. The CD memory has now been created. The CD should be retrieved from the computer and stored in a CD box or other physical storage unit. Note: the cave image folder and files are still available on the host PC for further use.

5) To electronically transfer the cave image folder(s) to other computers attached to the host PC via the MACA LAN, perform the appropriate file selection and send routine as agreed-upon

by the file "sender" and the file "receiver", or as determined by the project leader and program coordinator. Options include transferring (sending) files to a common LAN server location, where they can be accessed by many users, and sending or transferring the files directly to a designated personal directory on the LAN. Note: folders will remain on the host PC until they are deleted. Be Aware! Large image folders can rapidly accumulate and fill up even a large hard-drive.

6) Continue saving image files to CD memory by following steps 1-4 above, until all files for the sampling event have been recorded. The individual (photographer or other project team member or designated staff member) performing this CD creation step will collect all of the labeled CD's and deliver them to the project leader, who will ensure the CD are properly stored for archiving. Perform electronic file transfer (step 5) if and when needed to support image analysis steps. Note: CD may be effectively used for image file transfer, providing that the computer used for image analysis has an appropriate CD drive.

II. Performing Image Analysis to Collect Data on Crickets

Analysis of plot images to collect data on "passively captured" crickets is the central and core component of the Plot-Based methodology used for assessing the **structure of cricket populations** in caves. This analysis process is used to extract information or data from the images collected through performance of the plot photography steps described in SOP 3a ("Plot-Based Sampling"). Designated personnel will evaluate and mark-up each plot image and collect data on the organisms seen in that image, and will enter these data onto paper **Image Data Forms** (data entry is described in Section III of this SOP), followed by storing and preparing for archiving the processed images. Image analysis will yield data on a cave-by-region-by-plot-by-date basis on: **numbers** of *Hadenoecus* and *Ceuthophilus* individuals "captured" in the plot (image), the **relative size-class** and **sex** of observed *Hadenoecus* individuals, and the **apparent damage** suffered by observed *Hadenoecus* individuals, as manifest by detecting loss of legs and antennae. These data will be later analyzed to detect shifts in population structure that may be occurring in MACA caves over time in possible correlation with various natural and anthropogenic events and actions (see Protocol Narrative for monitoring objectives and discussion).

Image analysis can be effectively performed by any project and program person ("Image Analysts") who is capable and available for this task. Image analysis is a quickly-learned skill that should be developed by practicing ("On-the-Job-Training") using sample images under the guidance of an experienced individual. The primary skills needed include recognition of the cricket taxa (*Hadenoecus* and *Ceuthophilus*), recognition of sexual structures of larger individuals, recognition of the 4 relative size-classes of *Hadenoecus* individuals, and ability to discern possible missing legs and antennae. Analysts are also provided with reference standards and materials, such as photographs showing sexual anatomy and features that help distinguish among size-classes, to assist them while performing these tasks. In addition, every plot image will have a metric ruler or scale imbedded in the image, which will provide an in-image reference for making size comparisons and determinations.

In general, all tasks involved in both image analysis and the associated entry of image data into the data forms may be performed by a single individual. It is recommended that these tasks be performed by teams of two, as individuals can effectively assist and verify decisions being made during the analysis and data entry processes. Image analysis can begin as soon as some image files become available, and need not wait until after all sampling is complete to begin. It is expected that image analysis and the associated data entry will take up to one work-week per sampling event. The major steps or components of the image analysis process are: obtain cave folders, open images in the imaging utility, examine and label individuals, transfer data to data forms, and save marked images for archiving. The following steps will provide a chronological sequence of these tasks and some associated commands. The details of data entry onto the data forms will be presented in the following section (Section III).

Before Analyzing any Images

1) Turn on computer and log-in using appropriate procedures.

2) Ensure that the computer being used has available the desired image editor application. Current practice and the steps described herein are based on using **KodakImaging**, which is available on most MACA PC's. KodakImaging, and many other imaging applications, support the use of image marking tools, such as "rubber stamps". Use of "rubber stamps" is a key component in the process developed for "best" handling images during analysis.

3) Obtain a cave image folder (set of image files) for analysis. This may be (1) already in place on your computer, if using the PC that was used in image processing (Section I), (2) obtained in CD form by accessing the cave folders CD, or (3) obtained via transfer through the MACA LAN.

View and Analyze Images

1) Open cave folder and view image list or icons.

2) View the 1, 2, or several images available for a plot. Note: There will be at least one, and maybe several, images for a given plot. Only one image will be analyzed for each plot. The analyst will open and compare among the images of the plot to select the single "best" image for analysis. Open each image in **KodakImaging** and briefly inspect it. Compare among the plot's images to find the one that has the most crickets. This image will usually be the "best" one for analysis, as it offers the most data.

3) Select the "best" image and transfer it to the active "desktop" using a "copy" command or drag-and-drop. Repeat steps 1-3 until you have transferred one "best" image for each of the 16 plots photographed in the cave. Note: handle and analyze only one cave folder at a time, which should yield not more than 16 "best" images for analysis.
4) Change the **attributes** of each image **on the desktop** from "read only" to "accessible" by right-clicking on image icon, go to "properties" on menu, de-select the "read only" attribute item, and click "OK" to return to the desktop. Repeat until all desktop images are accessible.

5) Open any one desktop image for analysis. The analyst may analyze the images for the cave in any order. Left-click on an image icon. You will get a "pull-down menu" showing options for where and how you want to open the image file. Select **KodakImaging**, double-click and the image will open within this application. Figure 4.2.1 Example of a "raw" ready for image marking (stamping) and analysis.

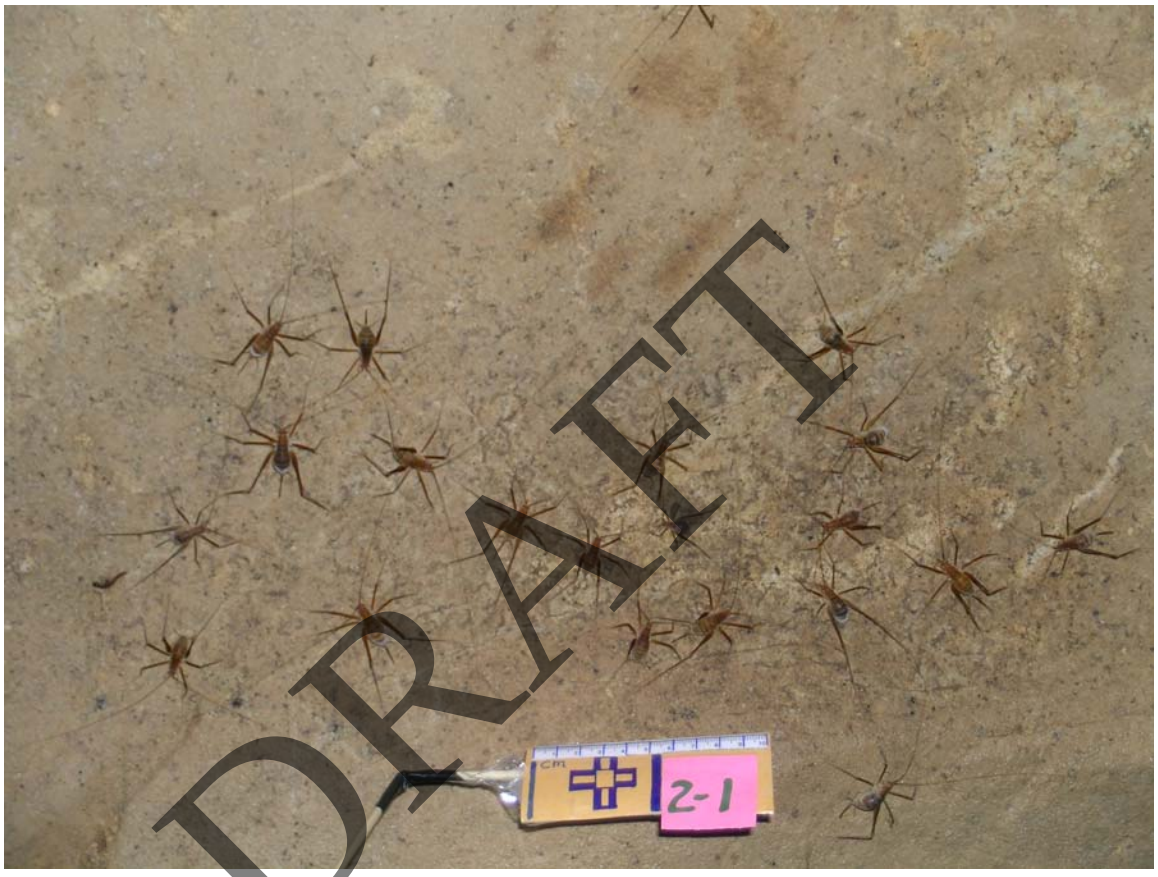


Figure 4.2.2. An un-marked "raw" plot image ready for analysis. Note the plot-label sticker and attached ruler as an available in-image size reference tool.

6) Once the image is open, scan the entire image to develop an overview of who and what is where in the plot captured. Use the toolbar "zoom" and "highlighter" features as needed to look at crickets. The highlighter will temporarily change the color of the image, which may help reveal smaller and less "contrasting" individuals.

7) After scanning the **first image to be analyzed for the sampling event**, go to the top toolbar on the screen and click on the **"annotate"** tool. This will open a series of menus that are used to build a set of "rubber stamps" that can be used to mark individual *Hadenoecus* crickets and record how they were classified as to size during this analysis. Create a set of stamps. Each stamp will have a size-class number (1 to 4) and a color (colors make it easier to find "stamps" in the image). To create a stamp: select "annotate", select "rubber stamps", select "create text", enter "size class (1, 2, 3 or 4)" into the "stamp name" field, enter a size number (1, 2…) into the "stamp text" field, select "font", select "size" = 20, select "style" = bold,

select “font type” = Courier, select “color” (pull-down list), select the color desired (aqua for 4, yellow for 3, lime for 2, red for 1), click “OK” to close this “annotation” window. The 4 size-specific rubber stamps have been created, and will remain available in KodakImaging until they are removed. Note: The stamp-creation step is a **one-time-event**. Closing the “annotation” window returns you to the image.

8) After creating your stamps (or after opening the first image in a cave image folder) you need to create a new “marked cave-by-date” folder to receive saved, marked images for archiving. To create a new folder, use the MS-Windows steps to create a new folder, and name it with the current cave folder name, plus an “m”, to denote “marked” images. Example: FN 100304 cricket pix **M.** Go to your open image to view crickets.

9) View the image and pick a cricket to start the data collection sequence. Generally, start with a cricket located on one side of the image, so that you can proceed across the image in some path. Examine this individual and determine its **relative size class**. This is a “practiced skill”. Compare this individual to others in the image, and/or refer to the imbedded ruler in the image, if helpful to making this decision.

10) “Stamp” the individual with the appropriate size stamp. Click on the “stamp” tool, choose the stamp you want, and click on the cricket. The stamp will appear wherever the cursor is. The stamp may be clicked-on and dragged or relocated, and it may be “grabbed” and enlarged or shrunk, as desired. Generally, place the stamp to the right of the cricket’s body, if this does not occlude another individual. Note: Stamps are moveable while this image is open. Once the (marked) image is saved, stamps become permanent, fixed changes to the image.

11) Examine the stamped individual to determine its sex (if a size 3 or 4 cricket), and count the visible legs and antennae. Note: any and all of these parameters may not be wholly visible or clearly discernable. If unable to confidently determine an individual’s sex, or unable to clearly decide how many legs and/or antennae it may have lost, these parameters may be recorded on the data form as “unknown” (U).

12) Record the data for this individual on the data form. If working in a team, one member will be serving as the data entry person. The observer will verbally relay his/her decisions (data) to the recorder, who will enter data into the data form, per steps in Section IV. If working alone, the analyst enters his/her data into the data form.

13) Go on to the next cricket. Repeat steps 9 – 12 above for each individual seen in the image.

14) After all crickets have been stamped and evaluated, and data has been entered, review the entire image once more to ensure that all individuals were seen. Stamped crickets were seen, but it is possible that some smaller individuals, particularly size 1 and smaller size 2, could have been skipped. Use the “highlighter” tool to change the image color to better see some of these individuals.

15) Save the marked image into a **new cave image** folder (FN 100304 cricket pix M) on this computer. You will **rename** the image file to save it in the marked folder. Click “File”, select

"save as", select "my documents", select marked cave folder by name, open folder, enter image file name with an **M** to denote it being modified, and select "save" to save the modified image. See Figure 4.2.2 Example of a marked image showing "stamps".

16) Close the current image. **Check the image data form for completeness, and ensure that all data have been entered as needed.**

17) Delete this image from the **active "desktop".** Move to another image file, open it, and repeat the analysis and storage steps (9-16 above). When all 16 images have been analyzed and marked and saved, the "desktop" should be vacant of images for this cave. You are now ready to move to the next cave folder for the sampling event.

Figure 4.2.2. A "marked" plot image showing "stamped" crickets in 3 size-classes.

Image analysis, as described above, will result in creation of a second set of cave image folders (the "modified" set). These will be transferred to CD media for archiving using the same routine and steps as used for the original ("raw") images and folders. The modified images will provide a comparable data set that may be reviewed and analyzed at a later date to evaluate sampling and analysis patterns and trends. They can also serve as training aids when training analysts to

perform all steps in image evaluation. Use the procedure and steps detailed in Section I, “Save Images to a CD for Archiving…”above.

III. Recording Individual Cricket Data on the Image Analysis Data Form

Data collected during analysis of plot images, as described in Section II above, is entered onto a paper **Image Data Form** by image analyst(s) during the course of analysis. Generally, if analysis is being performed by a two-person team, one member will enter data for an image onto the form page or sheet, while the other is doing the on-screen evaluation of “captured” crickets. If analysis is being performed by a single analyst, that individual will enter his/her own data onto the data form as data are collected. In either case, data entry is essentially simultaneous to data collection, and data are entered as each individual cricket is evaluated. The Image Data Form is a paper form with data blocks and columns. To improve data verifiability and simplify entering of data, most data blocks are designed as “check-boxes”, arranged in column-fields for different types of data. Each row on the form represents an evaluated *Hadenoecus* individual. Sets of check-boxes are arranged in columns for sex, size-class, and possible numbers of legs and antennae. A set of summary data boxes are provided at the foot of each column to permit on-the-form summing of counts for each column (class, sex, etc.). Data fields (lines) are provided for recording sampling date, analysis date, analyst(s) ID, plot image ID (= cave, region and plot and image-in-plot ID’s), analysis start- and end-times, and a page-number for potential use of 2 sheets for 1 image. See Sample Image Data Form, Figure 4.3.1 Note: the data form can hold data for up to 94 individual *Hadenoecus.* While no single image has contained more than 78 individuals, to date, this does not preclude the possibility of getting as many as 250 or more crickets in a plot. In which case, multiple data sheets will be used, and pagination would be useful for tracking all pages or sheets. The following steps indicate the data, with examples, to be entered in the different fields. Data entry order is described as used in current practice, but is not firmly prescribed. It is critical that all data fields receive an entry, and that the image data form is reviewed for completeness and verified for data content prior to closing the image being recorded.

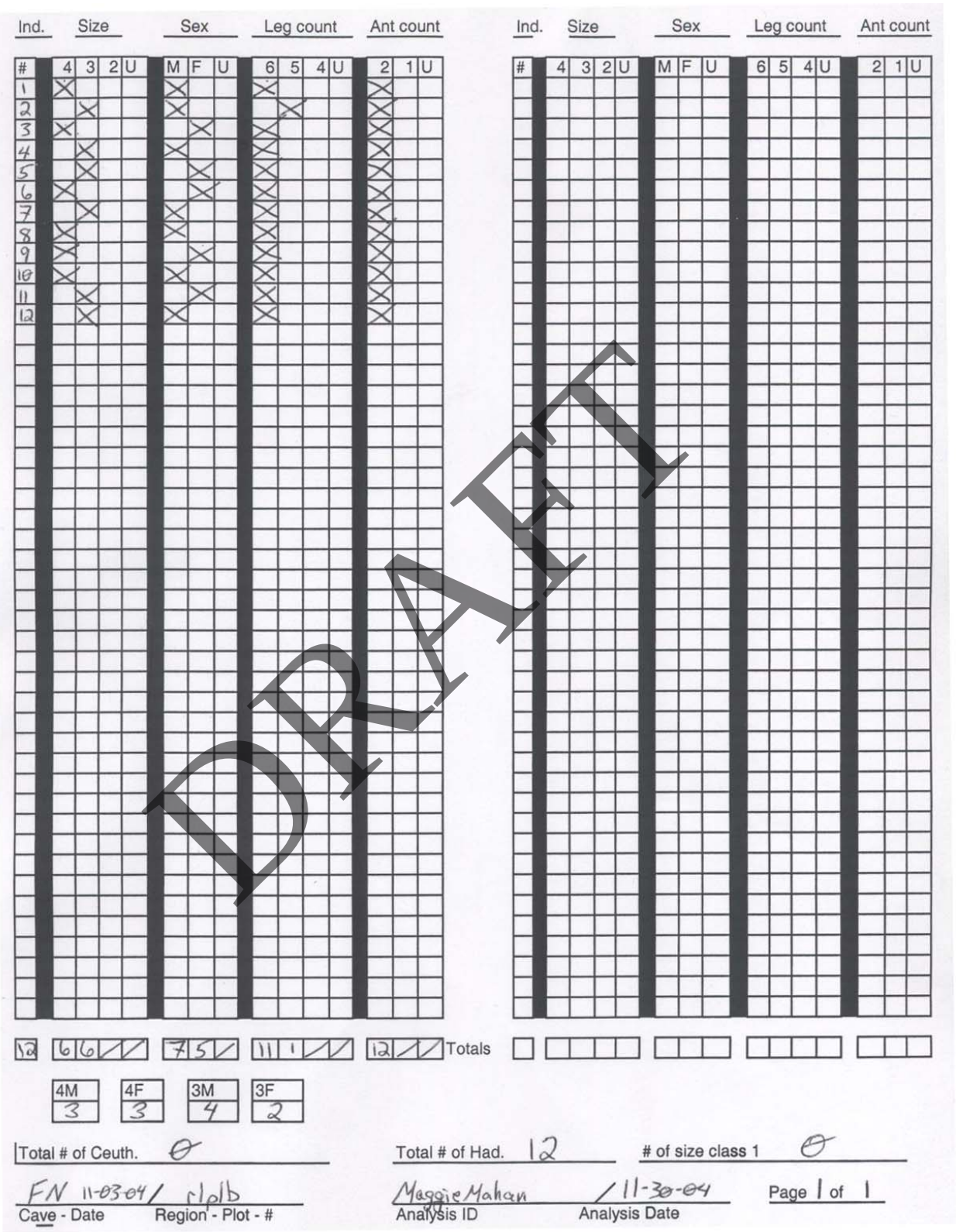


Figure 4.3.1 Example of a marked or completed Image Data Form.

Procedure:

Before Entering Data

1) Ensure that there is an adequate supply of blank Image Data Forms on hand. Forms may be photo-copied as needed. Master copies are available from the MACA project office or from the project leader.

2) Ensure that PENCILS, either #2 or # 2-1/2 wood pencils, or equivalent mechanical pencils, are available. Data should be entered clearly and legibly in pencil. Ensure that all marks and characters are clean and easily seen. If erasures are made, ensure that erasure is complete.

Enter Cricket Data for the Image

1) Enter the sampled cave ID and sampling date (Cave + Date): Cave is a 2-letter code, date is MM-DD-YY. These data are extracted from the Plot Image ID for the image file being analyzed. Example: FN 10-27-04

2) Enter the sampled region ID, plot ID, and image-in-plot letter (Region + Plot - #): Region is an "r" followed by a 1 or 2, Plot is a "p" followed by single digit (1 to 8), -# (image-in-plot) is a single lower-case letter, a to g. Example: r1p6a

3) Enter Analyst ID (Analyst ID): Print one or 2 Names. Example: Mahon, M., or Maggie Mahon.

4) Enter the image analysis date (Analysis Date): Use MM-DD-YY. Example: 12-16-04

5) Enter analysis start-time (Time: **Start** & Stop): Use 24-hour clock. Example: 1345 for 1:45 pm

6) Go To first Individual Cricket (*Hadenoecus*) line. Start entering data.

7) Enter individual number (Ind#): Use 2 or 3 digits, counting in numerical sequence order. Example: 04 or 51

8) Enter size-class (Size): Put an "X" in the appropriate numbered column, 4,3,2,U. If size is not determined, use the "U" column. Example: "X" in column 4, if a size 4.

9) Enter sex (Sex): Put an "X" in the appropriate lettered column, M,F,U. If sex is not determined, use the "U" column.

10) Enter number of legs (Leg Count): Put an "X" in the appropriate numbered column, 6,5,4,U. If leg number is not determined, use the "U" column. Note: Assume that no individual will have 3 or fewer legs.

11) Enter number of antennae (Ant. Count): Put an "X" in the appropriate numbered column, 2,1,U. If antennae number is not determined, use the "U" column. Note: Assume that no individual will have no (0) antennae.

12) Go To the "Totals" line at foot of columns. Calculate a total for each column by counting checked boxes in that column. Enter the totals in their respective columns.

13) Go To the set of summary boxes that enumerate individuals by size-class-by-sex (number of male size 4 = "4M", number of female size 4 = "3M", etc.). Count the appropriate individuals and put these sums in their appropriate summary boxes. Example: 4M = 8, 4F = 12, 3M = 7, 3F = 1.

14) Enter total number of *Ceuthophilus* in image (Total # Ceuth.): Count all *Ceuthophilu*s noted as "hash-marks" on this line, indicate as a sum. Example: //// = 4

15) Enter total number of *Hadenoecus* in image (Total # Had.): Count all *Hadenoecus* seen in image by counting the filled individual data lines. Indicate this total as a sum. Example: 28 lines = 28

16) Enter total number of *Hadenoecus* "**size 1**" seen in image (# Size class 1): Count all *Hadenoecus* size 1 crickets noted as "hash-marks" on this line, and indicate as a sum. Example: /// = 3, or no marks = 0

17) Enter analysis end-time (Time: Start & **Stop.**). Use 24-hour clock. Example: 1423 for 2:23 pm. Note: This should be the last datum entered on this data form sheet.

Once the Image Data Form is complete and all data have been entered for this image, **STOP**. Examine the form for completeness. Ensure that each cricket data line has **one entry only** in each set of columns (Ind#, Size, Sex, Leg#, Ant#). Ensure that the Cave-Date-Region-Plot-# spaces have a complete, legible entry. Ensure that analysis start and stop times are entered. Ensure that data analyst(s) names are entered. Ensure that all summary and "totals" blocks and lines have an entry. Once these have been verified by the analyst(s), the image being recorded may be saved, closed, and removed from the active "desktop". The data forms will be assembled together for the day's analysis activities and handed over to the project leader, who will secure these records pending electronic data entry into the project database (see SOP 5 "Post-Sampling" and SOP 6 "Data Entry").

IV. Post-Analysis Image Archiving and Assembly of Data Forms

Procedures and steps of image downloading and initial processing resulted in creation of a set of cave image folders, each containing a set of 35-50 jpg. images taken of plots sampled in that cave. These are the "raw" (un-marked) image files that are a), analyzed for cricket-associated data, and b), archived as a permanent image record of sampling in caves. Section I of this SOP specified that the "raw" folders and images are to be downloaded or transferred and saved on CD

memory media for archiving at the MACA project office. Section II specifies that "raw" images will be copied and converted into "marked" images, and that these images will be transferred to CD storage media for archiving at the MACA project office. "Raw" or original image files will also be archived with the project database and under control of CUPN-MACA data management personnel. This archiving will be performed as per the guidelines and procedures established under the CUPN-MACA Data Management Plan, and as summarized in SOP 6 "Data Management" of this protocol.

Image Data Forms completed following analysis of plot images will be collected by the project leader, who will ensure that data forms are a) securely stored pending electronic data entry, and b), entered into project archives for permanent storage (see SOP 5 "Post-Sampling" and SOP 6, "Data Management" for routing).

Cave Cricket Monitoring Protocol for Mammoth Cave National Park

Standard Operating Procedure (SOP) # 5

Post-Sampling

Version 1.0 (July 18, 2003)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure explains procedures that all crew members using the Cave Cricket Monitoring Protocol for Mammoth Cave National Park, Kentucky should be familiar with and follow after a sampling event is completed.

I. Equipment Organizing/Cleaning Procedures:

Clean and repair all equipment prior to returning them to their designated storage space in the Science and Resources Management biology laboratory. All references manuals should be re-shelved on their appropriate bookshelf. Other reference materials and extra data sheets need to be filed in their appropriate filing cabinet. Clean the insides of all vehicles used in the field. All cave gate/door and cave road gate keys should be returned. Table 5.1 provides a convenient post-event logistical checklist for the project leader's reference.

II. Data Chain of Custody and Entry Procedures:

On the same day of the sampling event the project crew leaders should organize field data sheets and verify they have been filled out completely. As a rule, all data sheets need to be reviewed for completeness before the crew leaves the field. However, because of the number of caves involved and crew members, some deficiencies in data recording may not be identified until all data sheet have been organized and reviewed as a group (e.g., when start and end time for a particular cave has inadvertently been missed by a sampling team). Once the field data sheets are checked and organized, the project crew leader gives them to the project leader. Finally, project crew leaders should download and label plot photographs to a dedicated network folder, burn the 'raw' images onto a CD, and archive the CD in a dedicated storage space.

Archiving field notes, transfer of data from paper to virtual data forms, and burning CDs with photographic data can all be accomplished at a later date. However, this process should be completed ca. one week after the sampling event and well before the next sampling event. These tasks are all performed by either Cumberland Piedmont Network staff or Mammoth Cave National Park Prototype Long-term Ecological Monitoring staff. The data chain of custody should be as controlled as possible so that no data are lost in the various steps involved in the process of transferring data from a paper medium to an electronic medium.

The project leader or designated crew member must transfer transect sampling data and event data (e.g., crew, date, etc.) from field data sheets, along with any pertinent data from field notebooks, to virtual data forms in the appropriate database (i.e., tblTransectObservation). Field data sheets are then archived in the dedicated storage space. Field notebooks will be placed in their dedicated storage space for repeat use in the next sampling event.

The project leader assigns an image analysis team to process the labeled cricket plot photographs previously stored by project crew leader in a dedicated network folder (see SOP #4 "Image analysis and image data entry"). The image analysis team reviews the photographs, marks them using a digital photo-processing program, and stores them in a dedicated network folder separate from the folder with the unmarked photographs. The image analysis team burns the marked photographs onto a CD and archives the CD in a dedicated storage space.

The image analysis team, preferably (although not necessary) the prior team, transcribes the data from the marked photographs onto pre-printed plot data sheets. The image analysis team enters the plot data from the pre-printed data sheets into virtual data forms in the appropriate database (i.e., tblCricketObservation) and archives the data sheets in a dedicated storage space. The project leader must then verify that 10 percent of the data are free from transcription errors. Project leader or designated crew member must obtain ancillary data needed, if any, prior to analysis of long-term plot and transect data. Data analyses and reports are stored in dedicated network folder and/or storage space.

Ancillary data must be identified and obtained. It is of critical importance that these data be incorporated into the cave cricket monitoring efforts. First and foremost, knowledge of management efforts inside and outside caves for that year (e.g., controlled burns) will be used to assess the effects of these efforts on cave cricket population structure and dynamics. Second, climatic data collected by the sampling team will assist in evaluating the effect of temperature and relative humidity on cave cricket distribution. Because cave crickets feed on the surface the frequency of their foraging bouts is strongly affected by surface weather patterns. For example, drought conditions limit plant growth and thus reduce food availability for cave crickets. Therefore, annual climate data will be obtained from the park weather station or from the National Park Service Air Resources Division.

Number Required		Description
		Post-Event Logistical Checklist (MM/DD/YYYY)
☐	1.	Inform surface watch of arrival
☐	2.	Erase crew sign out from dry erase board
☐	3.	Remove gear and refuse from field vehicles
☐	4.	Clean field gear as necessary
☐	5.	Store equipment in designated storage space in biology laboratory
☐	6.	Return cave door/gate keys and road gate keys as necessary
☐	7.	Enter sampling event data and transect data from notebooks onto virtual forms (Names of assigned crew members)
☐	8.	Download and label plot photographs to dedicated network folder, burn 'raw' images onto CD, and archive raw plot image CD (Names of assigned crew members)
☐	9.	Review and mark plot photographs from dedicated network folder, burn marked images onto CD, and archive marked plot image CD (Names of assigned crew members)
☐	10.	Transcribe plot data onto pre-printed plot data sheet (Names of assigned crew members)
☐	11.	Enter plot data onto virtual forms and archive pre-printed data sheets (Names of assigned crew members)
☐	12.	Project leader vets/verifies data
☐	13.	Obtain ancillary data (Names of assigned crew members)
☐	14.	Analyze plot and transect data (Names of assigned crew members)

Table 5.1. Post trip logistical checklist. All tasks below dashed line can be completed at a later date but no later than ca. 1 week after sampling event. Project leaders may want to print this checklist for use as a reference and attach to event report.

Cave Cricket Monitoring Protocol for Mammoth Cave National Park

Standard Operating Procedure (SOP) # 6

Data Management

Version 1.0 (December 2004)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

I. Introduction

Purpose

This SOP provides instructions for the development, maintenance and distribution of monitoring data associated with the protocol for monitoring cave crickets in the Mammoth Cave National Park Prototype (MACA). The cave cricket protocol is one of 17 identified vital signs monitoring protocols currently slated for development by the Cumberland Piedmont Network (CUPN)-MACA Monitoring program. Per national IM Program guidance, Microsoft Access XP (2002) is the primary software environment being utilized for desktop database applications. Data and data products will be archived, backed-up, and distributed per the guidance contained in the CUPN-MACA data management plan (DMP). It is the responsibility of the data manager to be thoroughly familiar with the standards and procedures within the DMP and ensure this SOP is updated to reflect any substantive changes made to the DMP. All proposed changes to this SOP must be routed through the data manager for approval. QA/QC guidelines in this document are based on the general concepts defined in Chapter 6 of the DMP.

Expected Audience

This SOP is written specifically for the protocol data manager, protocol project leader, and project crew members. In all cases, it is intended that this SOP will reduce the overall time needed to accomplish required tasks performed by each type of reader. To accomplish this goal:

- Protocol data mangers will want to read the entire SOP like a text book and be familiar with all aspects of the document. Data managers should be looking for ways to improve the system, but must first know the system being used.
- Protocol project leaders may want to only skim the document, paying particular attention to the data flow and handling procedures (see Appendix B, QA/QC Process Flow). Project leaders are responsible for understanding and fulfilling the data stewardship tasks assigned their role, as well as ensuring that anyone under their supervision understands and fulfills their assigned responsibilities. Data stewardship roles and responsibilities can

be found in Chapter II of the DMP and its associated appendix (Appendix B, Data Stewardship Roles and Responsibilities). Appendix C of this SOP contains a list of pertinent data stewardship roles for this protocol per the framework within the DMP.

II. Cave Cricket Database - Metadata

Metadata, or data about the data, include two basic categories: 1) the data structure information or data dictionary, and 2) data that describe the environment surrounding the purpose of the study. The data dictionary includes information such as field name, field type, field length, etc. The second category of metadata would include, for example, the contact information of the sample collector (name, address, phone number, etc.), or information about the location from which the sample was taken. These are metadata. The "real" data may be, for example, the attributes of cave crickets--that are of no value whatsoever unless accurate metadata are associated with the cave cricket data. The importance of accurate metadata cannot be overemphasized.

Because of the importance of metadata, much effort has been exerted both by the NPS and the developers of this project to insure useful metadata. Tables and data structures found in the I&M Program's Natural Resource Database Template (NRDT) were used as the foundation of the database. Cricket detail data and metadata tables and relationships were developed specifically for this project and are discussed in the following section. The project leader will complete a basic metadata survey form for inclusion in the data manager's project file. The data manager will utilize this information to create a Dataset Catalog record. Dataset Catalog, which was also developed by the I&M Program, provides a means whereby CUPN-MACA can organize, maintain, and disseminate brief metadata on its dataset holdings. It is the shared responsibility of the project leader and data manager to ensure this record is accurate and up to date. The Dataset Catalog export function can be used to generate output in the text-based FGDC-compliant metadata format that can than be imported into ArcGis for documentation of associated GIS layers. All sample locations will be documented via a GIS layer created from tluCave_Locations fields. GIS layers will be documented with appropriate FGDC compliant metadata.

III. Cave Cricket Database - Data Model

The general data model for cave cricket monitoring consists of metadata described above and field collection data. Proper linking of these datasets is critical to effective long-term monitoring and analysis of cave cricket population structure and dynamics and provides researchers and policy makers with information necessary to make correct decisions regarding the use and conservation of the parks' natural resources. It should be noted that recent (December 2004, i.e., NRDT Phase III) proposed changes made to the NRDT will likely result in significant changes to the data model presented in this SOP, as the sampling methodology and data model are further developed.

Standardized Naming Convention

To help manage the data model a standardized naming convention has been adopted, using the NRDT (i.e., phase II) tables and structure where possible. For other tables and forms within MS Access, the naming convention of the NRDT database is generally followed. For example, the table that contains the location data is called "tluCave_Locations" and has the exact structure as

the NRDT table, tblLocations, but with additional "cave specific" fields. The decision to "break out" cave location information from other locations was made in large measure due to its recognized sensitivity.

Cave cricket Data Model

Figure 6.1 includes the core tables and project-specific tables used to store the collected data for this cave cricket monitoring protocol. This protocol is essentially two sub-protocols in one. The first method of data collection employs a series of laser-delineated transects in which mere counts are recorded. With the second method of collection, individual cricket characteristics are recorded with digital photographs of aggregated crickets or "clusters" as they roost on cave ceilings. The project-specific data tables for these sub-protocols are tblTransectObservation and tblCricketObservation, respectively. It should be noted, there are additional common lookup tables within the data model, such as tluProjects and tluObservers which are not included in Figure 6.1. For a discussion on the distinctions between the three table "types" utilized in each CUPN-MACA protocol database (i.e., common lookup, core, and project-specific) the reader is referred to Section IV.3.1 (Project Database Structure) of the DMP.

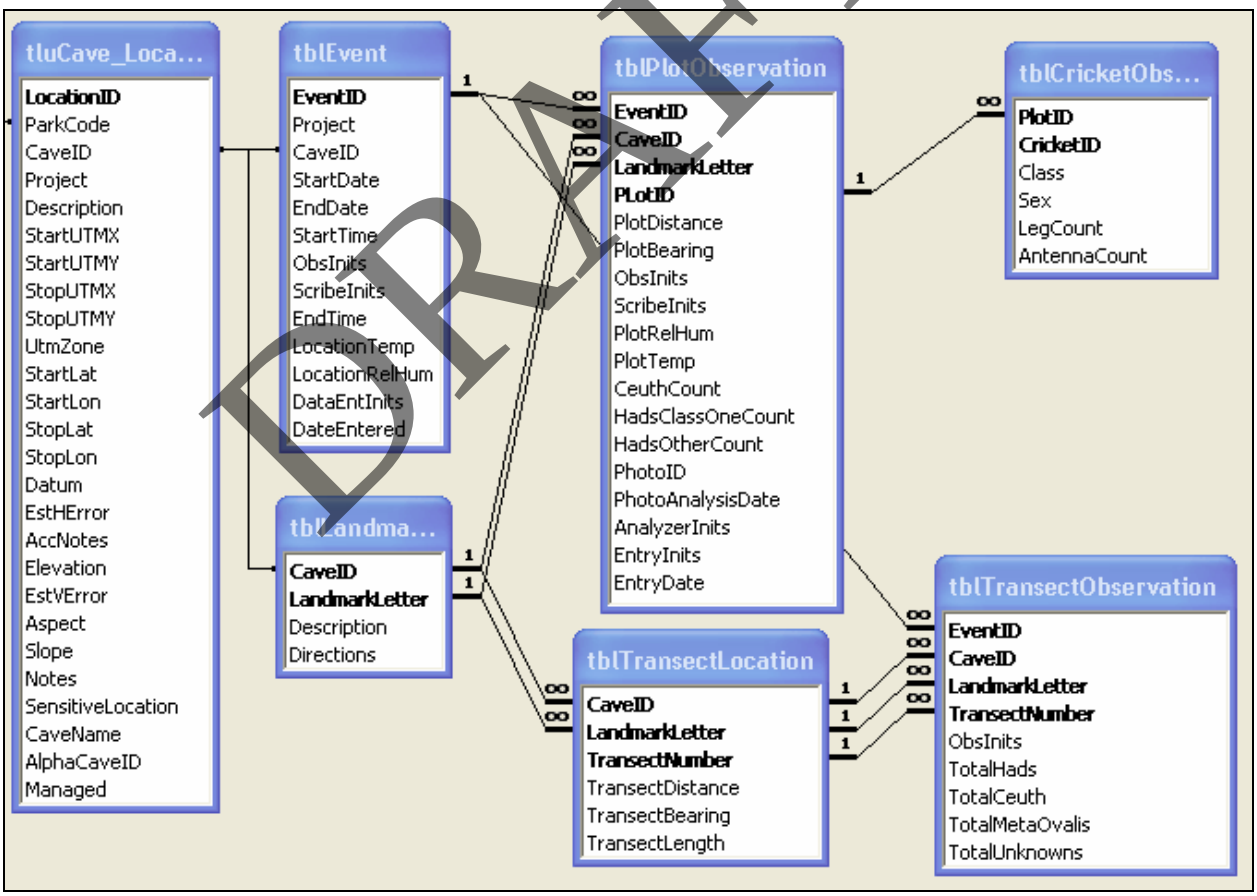


Figure 6.**1** Cave Cricket Data Model

IV. Data Flow and Data Entry

Data Flow

Periodically, crews will observe and record parameters on the cave crickets as detailed in the sampling plan (see SOPs #3a and 3b "Field Measures). Before leaving each plot or landmark, crew members will check their field data sheets to make sure all required data has been collected. Immediately upon returning from the field, observers will recheck their field sheets for completeness and accuracy. After rechecking the field data forms for accuracy and completeness, field data are entered into an MS Access database form (refer to Appendix A). The data will then be checked by the project leader using queries designed to find erroneous entries. After certifying the validity of the data content for that collection period, the project leader will export the data from the database and send it to the data manager who will certify the format and overall reliability of the data. The dataset will then be stored as read-only in the DBMS_Master subfolder of the Crickets folder (Figure 6.2). Archived and fully documented datasets and associated metadata can be uploaded to the NR-GIS Metadata and Data Store, once this system becomes fully operational. The general flow of data and QA/QC process steps are presented in Appendix B.

Data Entry

Extensive use of programmatic data validation has been incorporated to greatly reduce the number of operator entry errors. Rather than direct database table entry, customized forms are being designed and tested that provide a natural flow of data entry into the database and validate the entered data before allowing them to be written to the database (see Appendix A). Where possible, data are entered via the use of dropdown lists or by typing the beginning characters of the value, thus eliminating the possibility of operator entry error. Lookup tables contain project specific data and prohibit entry of data into a field if a corresponding value is not included in the lookup table. For these fields, only valid names or measures may be entered and spelling mistakes are eliminated.

For the remaining data fields, validation controls prevent impossible values to be entered (e.g., a negative number of cave crickets) and data entry alert messages are provided any time a datum is entered that is not realistic (e.g., number of legs greater than 6). The user is offered a chance to reenter the data or keep the abnormal data. If the user okays the abnormal data, a log file is generated that lists pertinent information about the out-of-range data (e.g., sample number, fields, entry operator, sample collector, etc.). The log file is sent to the project leader.

V. Data Verification

In addition to data verification accomplished by the computer program, the data will also be manually verified shortly after data entry. This process involves checking the accuracy of computerized records against the original source, usually paper field records. While the goal of data entry is to achieve 100 percent correct entries, this is rarely accomplished. To minimize transcription errors, our policy is to verify 10 percent of the records to their original source by staff familiar with project design and field implementation.

The primary goal of data entry verification is to determine where errors are being introduced into the database. Each error found will, of course, be corrected, but will additionally be catalogued to find methods for eliminating that specific type of error during subsequent collection periods. For example, if data entry of a certain field is more prone to entry errors, a more stringent computer verification method will be created to eliminate that error from occurring. Once the computerized data are verified as accurately reflecting the original field data, the project leader can submit original field forms for archival. The electronic version of the data is used for all subsequent data activities.

VI. Data Validation

In addition to the computerized data validation process described above, manual data validation is performed during the manual verification process. The project leader will validate the data after verification is complete. Validation procedures seek to identify generic errors (e.g. missing, mismatched, or duplicate records and comparison of QA/QC data with corresponding sample data). Again, because of the design of the database and entry form table relationships and linkages, most of the generic errors should have already been eliminated.

During the entry, verification, and validation phases, the project leader is responsible for the data. The project leader must assure consistency between field forms and the database by noting how and why any changes were made to the data on the original field forms. In general, changes made to the field forms should not be made via erasure, but rather through marginal notes or attached explanations. Once validation is complete, the dataset is turned over to the data manager for archiving and storage. Refer to Appendix B for a table of QA/QC process flow and procedures.

VII. Database Administration

Data Maintenance

Datasets are rarely static. They often change through additions, corrections, and improvements made following the archiving of a dataset. There are three main caveats to this process:

1) Only make changes that improve or update the data while maintaining data integrity.
2) Once archived, document any changes made to the dataset.
3) Be prepared to recover from mistakes made during editing.

Any editing of archived data is accomplished jointly by the project leader and data manager. Every change must be documented in the edit log and accompanied by an explanation that includes pre- and post-edit data descriptions.

Data Organization

The data are organized based on an object-oriented framework rather than the structured framework. That is, rather than grouping files based on function, files are grouped by object. For example, rather than placing the data for all vital signs in the same folder and all the narratives in another folder, the object-oriented paradigm suggests that placing all folders concerning an

object (i.e., vital sign) be placed together. Global objects such as Admin and GIS Layers have their own top-level folder.

Within the Cave Cricket object, Shared Data and Shared Docs are also considered independent objects. Within the Cave Cricket vital sign there are subfolders corresponding to each aspect of the protocol: DBMS_Master (validated and archived datasets), DBMS_BE (active tables), DBMS Forms, Documents, Images, etc. Figure 6.2 displays the general folder located on the MACA Science and Resources Management Division's shared directory (i.e., X drive) and the expanded folder structure for the cave cricket monitoring protocol.

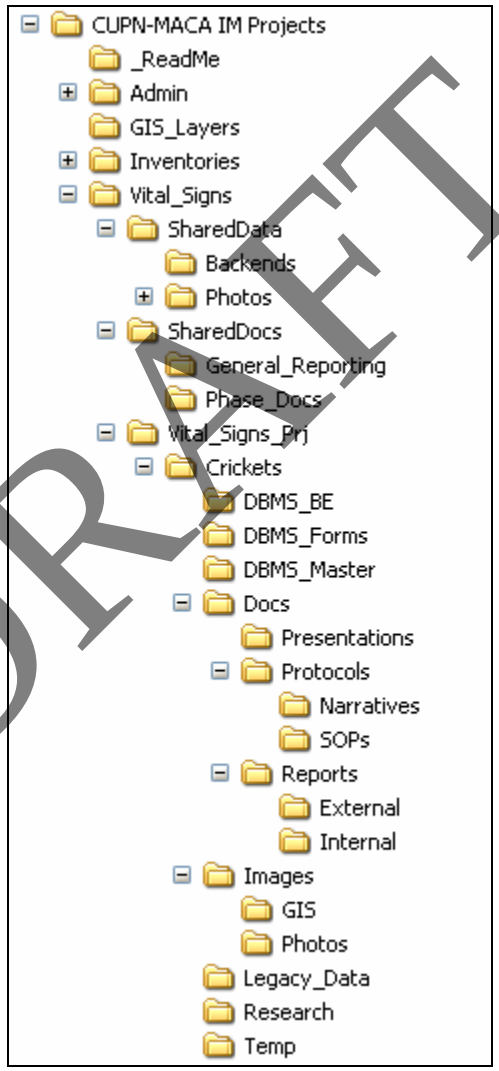


Figure 6.2 Folder Structure for Cave Cricket Monitoring Protocol.

Data Security and Integrity

As many different users will be accessing the database, it is imperative that the data remain secure. Although MS Access provides a means for allowing User-Level Securities to different

groups of uses, the data managers have determined that it will be more effective to create user groups within the local area network operating system that will have different security levels. Generally, three levels of users will be given different sets of permissions. CUPN-MACA data managers will have all permissions, including insert, delete, and modify for all folders in the folder structure. Project leaders/program coordinators, will have the same permissions as program data managers except for read-only permission to the shared data tables and archived data. Those entering the data will have insert-only permission to the observation data and read-only permission to the lookup and shared data tables.

Version Control

Prior to any major changes of a dataset, a copy is stored with the appropriate version number. This allows for the tracking of changes over time. With proper controls and communication, versioning ensures that only the most current version is used in any analysis. Versioning of archived datasets is handled by adding a three digit number to the file name, with the first version being numbered 001. Each new version is assigned a sequentially higher number. Frequent users of the data are notified of the updates, and provided with a copy of the most recent archived version.

Data Logs and Backups

Once the data are archived, any changes made to the data must be documented in an edit log. From this point forward, original field forms should not be altered. Field forms can be reconciled to the database through the use of the edit log. Secure data archiving is essential for protecting data files from corruption. Once a dataset has passed the QA/QC procedures specified in the protocol, the data manager will make a formal entry in Dataset Catalog. Subsequently, an electronic version of the dataset is maintained in a read-only format on the MACA server. Backup copies of the data are maintained at the MACA Prototype office. Incremental tape backups of all project databases are made nightly with a full tape backup being made every weekend. After each collection/validation cycle, a CDROM copy is placed into permanent archive.

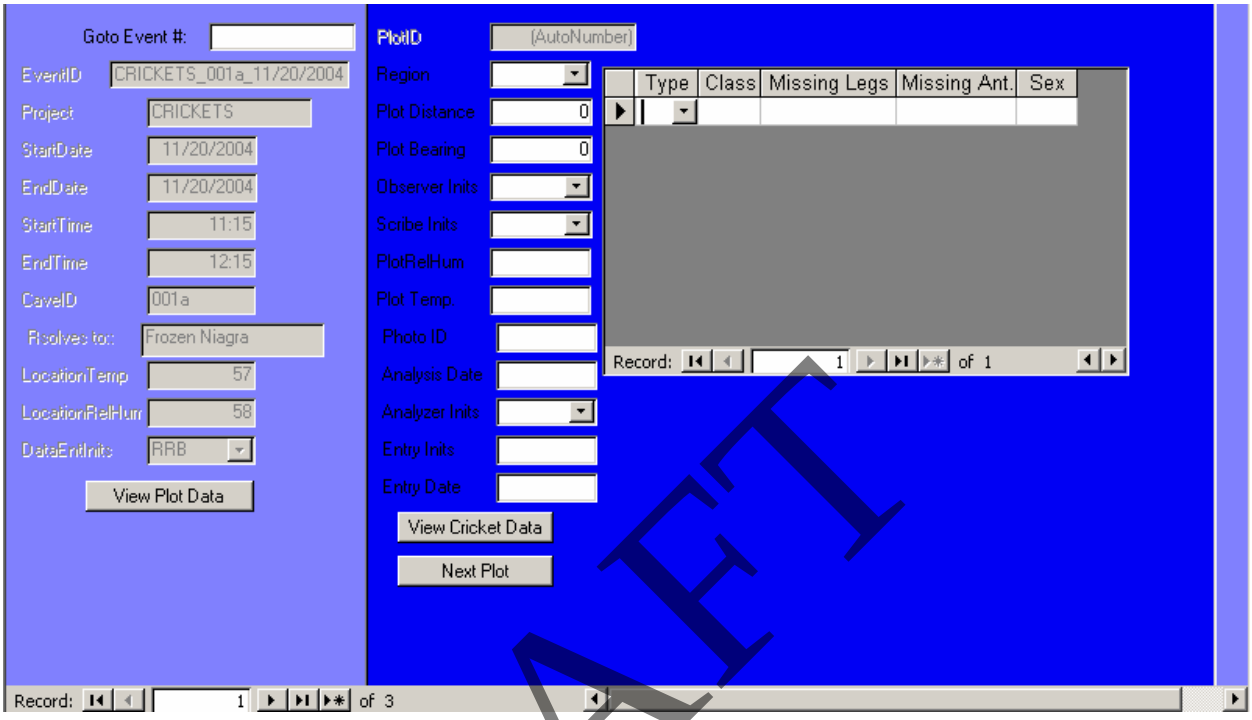
VIII. Data Availability

In addition to the "standardized" data dissemination strategies noted in Chapter IX of the DMP, data will be made available for research and management applications on request (per the framework established in the DMP). Data can be transferred using ftp. Data requests should be directed to the MACA prototype coordinator.

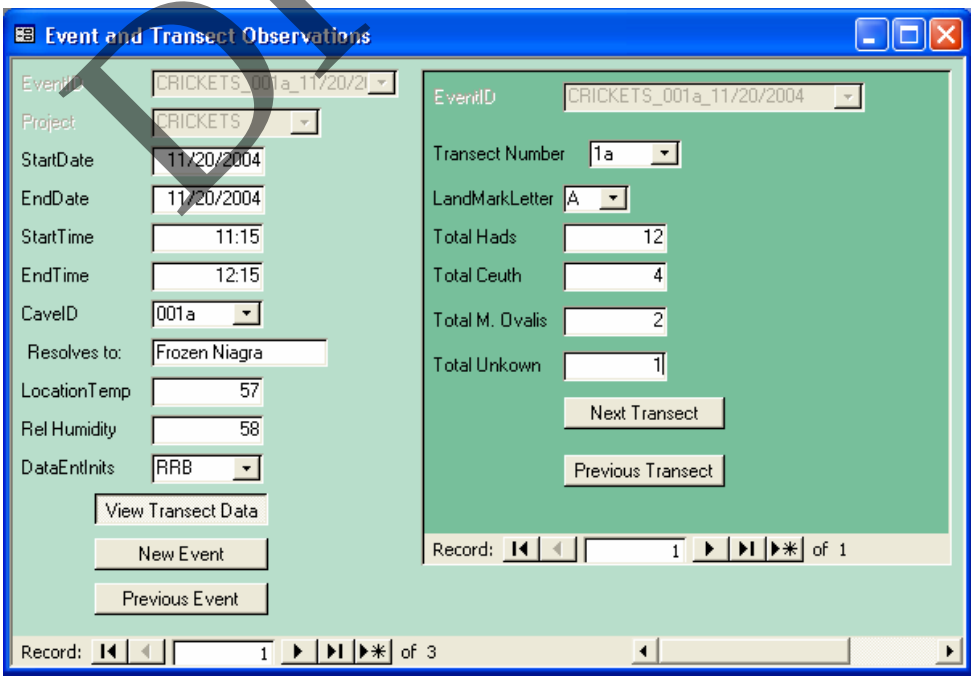
IX. Tables, Forms, Reports, and Queries

Current detailed table structure information such as field type, length, description, primary keys, and linking fields may be found in the MS Access database file Cave cricketxxx.mdb where xxx is the latest version. This file is located in the DBMS_BE folder within Crickets folder. Specific form, report, and query information are stored within the DBMS_Forms folder. In addition, most protocols within this vital signs monitoring program share common data such as observers, park codes, project codes, etc., which are stored in the SharedData/Backends folder.

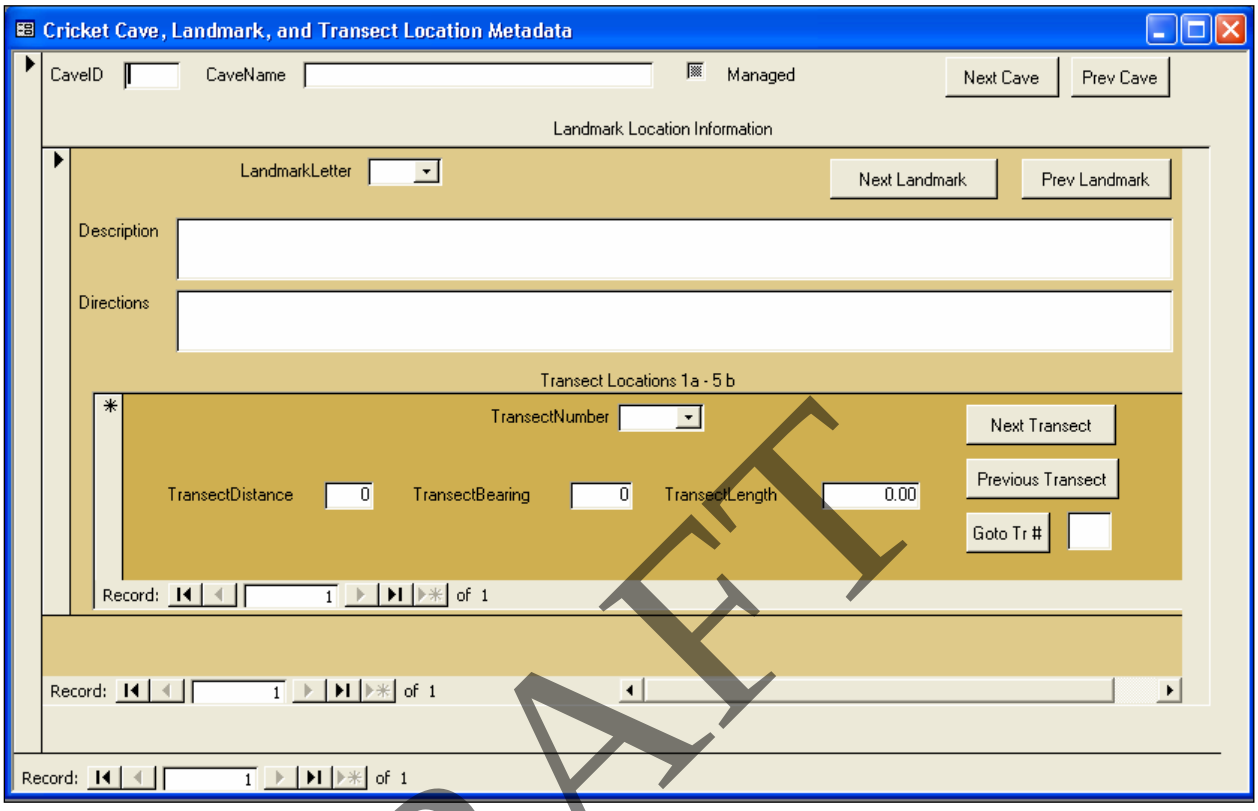
Appendix A. Sample Data Entry Forms



Sample Data Entry Form for Plot Data



Sample Data Entry Form for Transect Data



Sample Data Entry Form for Protocol Specific-Location Metadata

Appendix B. QA/QC Process Flow

QA/QC Procedure Name	Schedule	Description of Procedure	Responsible Entity	Response
Immediate Verification	**Before leaving each landmark or plot**	**Crew members will verify all data on their field forms pertaining to the current plot or transcect and proceeding to the next location**	**Crew Members**	**If there are blank or incorrect entries they will be corrected immediately. If a procedural change or new datasheet format could prevent future mistakes, the suggestion will be annotated in the notes.**
Field Notes Review	**Immediately after returning from the field**	**After the crew returns from the field the crew Leader will assure all datasheets are accounted for and complete**	**Crew Leader**	**Make sure all data have been entered and all data sheets are accounted for.**
Field Notes to Computer Form verification	**As entered**	**The person who enters the data into the computer from the field datasheets explicitly compares the paper datasheet with the data on the computer screen to verify correct data entry**	**Data Technician**	**Make corrections immediately and, if the errors could have been prevented by changing a process or computer form tell the data manager.**
Hardcopy-to-Digital Verification	**As soon as practicable, following previous step**	**10% of hardcopy records are compared to digital**	**Project Leader**	**Date and error types will be tracked using a standard form. Corrections will be made at time of check.**
Cricket DB Validation	**As soon as practicable, following previous step**	**Run validation queries and/or visual inspection. Once validation is complete save dataset as a read-only in "DBMS_Master"**	**Project Leader and Data Manager**	**Record any inconsistencies and import error messages. Correct problems and/or change process as needed. Provide feedback to data technicians and crew members as appropriate.**
National level database rollups	**Annually**	**Ensure dataset is fully documented and sensitive information is flagged**	**Data Manager and I&M Data Manager(s)**	

Appendix C. Data Stewardship Roles

This appendix contains a list of pertinent data stewardship roles for this protocol as defined in the DMP. For a comprehensive list of responsibilities assigned to each role refer to Appendix B, "Data Stewardship Roles and Responsibilities", of the DMP.

Role	Individual(s)/Entities	Duty Station / Title	Contact
Project Crew Member	Bill Moore	MACA / Prototype Ecologist/Data Manager	(270) 758-2161
	Kurt Helf	MACA / Prototype Ecologist	(270) 758-2145
	Lillian Scoggins	MACA / Prototype GIS Specialist	(270) 758-2149
	Johnathan Jernigan	MACA / Prototype Physical Scientist	(270) 758-2146
	TBD	MACA / WKU Biology Dept. Student Intern #1	(270) 745-
	TBD	MACA / WKU Biology Dept. Student Intern #2	(270) 745-
Information Technology Specialist	Pat Price	MACA / Supervisory IT Specialist	(270) 758-2130
Project Leader/Resource Specialist	Kurt Helf	MACA / Prototype Ecologist	(270) 758-2144
GIS Specialist	Lillian Scoggins	MACA / MACA Prototype GIS Specialist	(270) 758-2149
Data Manager	Bill Moore	MACA / Prototype Data Manager	(270) 758-2161
Curator	Brenda Bacon	MACA / Curatorial Assistant	(270) 758-2134
USGS Ecologist (term position)	Bob Woodman	MACA / USGS-BRD Ecologist	(270) 758-2148
Prototype Coordinator	Steve Thomas	MACA / MACA Prototype Coordinator	(270) 758-2144
Data Manager (National Level)		Fort Collins, CO / -	(970) 225-
End Users (managers, scientists, publics)	Multiple Entities	Multiple	Multiple

Cave Cricket Monitoring Protocol for Mammoth Cave National Park

Standard Operating Procedure (SOP) # 7

Data Analysis

Version 1.0 (December, 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP outlines the data flow and expected analyses of cave cricket monitoring data collected within Mammoth Cave National Park (MACA). The monitoring questions and subsequent analysis of the supporting data can be divided into two categories, based on time scale in analysis. The first category includes questions of status (population structure and relative abundance), natural trends in status and management – influenced trends in status, measured at the within-a-year and annual scale. This category focuses on detection of salient inter-seasonal natural patterns and trends, and detection of significant or dramatic influence on population trends due to both planned management activities, such as cave modification, and variable disturbance from cave tours. The second category includes the same questions, considered at longer, multi-year, scales. This category focuses on detection of multiple-year trends and natural patterns in cricket populations, and on detection of possible cumulative management effects that manifest themselves only after many years. Both categories of questions will be addressed using a combination of summary and descriptive statistics, graphic analysis, and multivariate inter-class comparative and correlative analysis. Management impact classes and time are the key grouping and stratification factors in the analyses of the several categories of cricket data (size and sex structure in the population, apparent damage rates suffered by the population, relative abundance and density). Three additional analytic approaches will be employed to evaluate crickets in a multi-species comparative and correlative model, cricket population dynamics relative to air physical parameter patterns, and spatial analysis of patch movement dynamics.

Within-a-year analysis will be performed sequentially as data are collected and analyzed in bi-monthly sampling events. Each event's data will be evaluated using a suite of descriptive and summary statistics. Inter-class multivariate comparative and correlative analysis will be performed on bi-monthly data sets. Interseasonal trends will be evaluated in short-term time-series analyses using the bi-monthly data sets. Long-term analyses will use both separate bi-monthly data sets and derived, cumulative annual data to evaluate longer-period trends and patterns.

The protocol was designed to answer three general monitoring questions:

1) What are the annual and longer-term trends in cave cricket population structure and dynamics in managed and unmanaged caves?
2) Do status and trends in cave cricket population structure and dynamics differ between managed and unmanaged caves?
3) Do status, annual, and long-term trends in selected population parameters correlate with specific management and visitation-related actions (e.g., cave structural modification, tour group frequency, cave lighting use, cave atmospheric conditions) occurring within managed caves?

I. Data Flow

The data manager will work with the project leader to ensure that data are regularly verified and rolled up into a master copy of the dataset in the "DBMS_Master" folder for this protocol (i.e., X\CUPN-MACA IM Projects…\Crickets\DBMS_Master). This folder is reserved for datasets that have already been validated, will no longer change, and with the exception of the data manager is available to Cumberland Piedmont Network-MACA (CUPN-MACA) staff with read-only access privileges. This ensures that once data are validated, the dataset remains accessible to staff while being secure from accidental or undocumented changes. This copy of the dataset, which is in .mdb format, should be utilized by CUPN-MACA staff for all analyses.

The development of basic queries and summary reports in MS Access will be utilized to automate and thus streamline the data analysis and reporting workload, as appropriate. In consultation with the project leader, the data manager will develop queries (and accompanying summary reports) that will address basic statistical questions including:

- Mean number of crickets per cave region per sampling event
- Mean size class per cave region per sampling event
- Sex ratios per cave region per sampling event
- Mean density of crickets per cave region per sampling event

These are basic questions which the project leader anticipates asking on an irregular but frequent basis in order to provide various "snapshots" of the current dataset. It is anticipated the results of these queries will be relied upon heavily for annual reporting requirements to the parks, as well as internal reports generated for CUPN-MACA staff and cooperators. The data manager will construct these queries and reports within the front-end of the current version of the protocol's MS Access database stored in the X:\CUPN-MACA IM Projects . . . \ Crickets \DBMS_Forms folder, which can be linked to the appropriate data tables on the MACA server. Note: This front-end database can be copied to the project leader's workstation in order to increase performance. However, the working and master back-end databases should remain on the MACA server in their respective folders at all times.

In instances where the statistical questions become increasingly complex, such as the long-term effects of management actions on cave cricket population structure and dynamics, data will need

to be exported out of the relational MS Access database to commercial off-the-shelf statistical packages. CUPN-MACA staff primarily utilize SigmaStat, Systat, and SigmaPlot for frequency distribution plots, test for normality, analysis of variance, time series analysis, etc. In these instances, the data manager will work with the USGS ecologist, project leader, and other CUPN-MACA staff to format data for export. In general, these data will be formatted based on parameters provided to the data manager via a make table query in MS Access. The generated table will be exported in ASCII text format.

II. Data Analysis

Data in comma delimited ASCII format are readily imported into statistical analysis software used at CUP-MACA (i.e., SigmaStat and SigmaPlot). The sequence of steps for data import within SigmaStat and SigmaPlot are:

1. Launch SigmaStat or SigmaPlot.
2. Click on File to view the File menu.
3. Select Import from the File menu.
4. A window will open in which the user can select the appropriate file type and the file to be imported. There will be a drop-down list from which the appropriate file type may be selected. Select "Plain Text." Then, navigate to the appropriate folder and select the desired file.
5. Now a new window is launched in which the field format must be indicated. Select "Delimiter" and the comma from the associated drop-down list. Click on "Import."

We anticipate that analyses will explore the behavior of cave cricket sample parameters over time. Of particular interest are variability in sex ratios, size class ratios, and damage indices (i.e. number of antennae and legs). Data managers will provide make table queries within the database or, upon request, data tables that include means for these parameters. These data will be imported into SigmaStat or SigmaPlot for higher level statistical analyses (i.e. t-tests and ANOVA). An example of short-term inter-regional trend depiction is shown in Figure 7.1. An example of the type of data that will be made available by data management is shown in Figure 7.2.

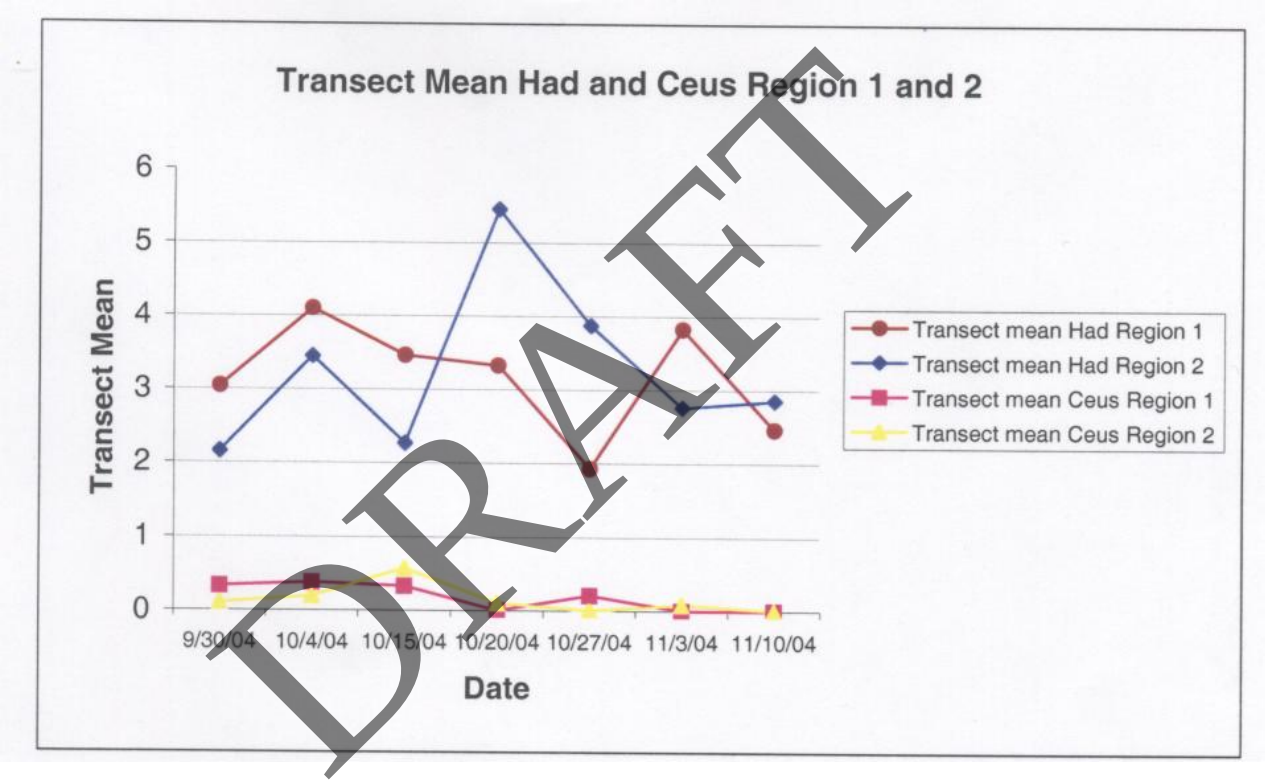
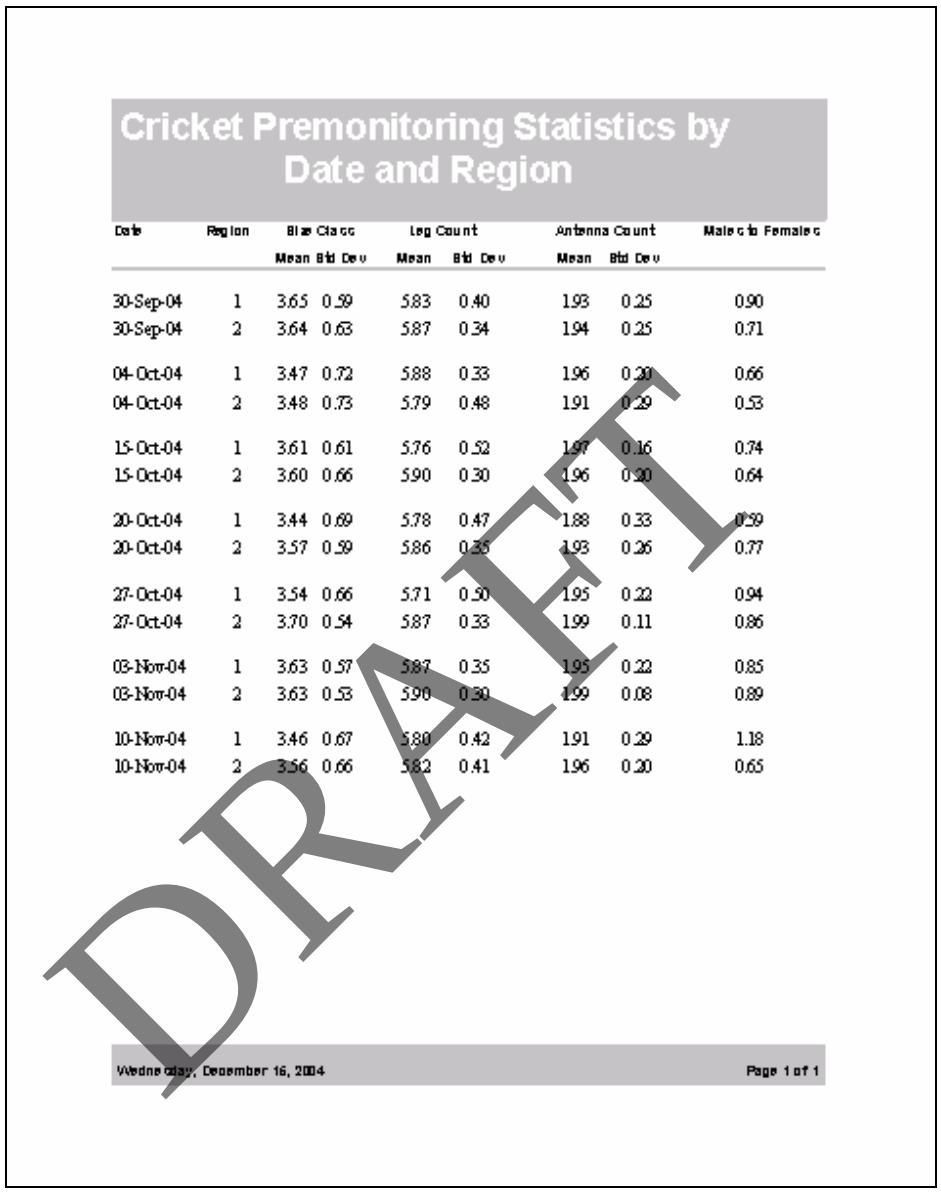


Figure 7.1. Mean estimated densities for two species of crickets recorded in 2 regions of Frozen Niagara cave (MACA) over the short-term sampling test performed in Fall 2004. Note: transect means reflect correction for varied lengths among the virtual transects sampled.



Cricket Premonitoring Statistics by Date and Region

Date	Region	Blue Class		Leg Count		Antenna Count		Male to Female
		Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	
30-Sep-04	1	3.65	0.59	5.83	0.40	1.93	0.25	0.90
30-Sep-04	2	3.64	0.63	5.87	0.34	1.94	0.25	0.71
04-Oct-04	1	3.47	0.72	5.88	0.33	1.96	0.20	0.66
04-Oct-04	2	3.48	0.73	5.79	0.48	1.91	0.29	0.53
15-Oct-04	1	3.61	0.61	5.76	0.52	1.97	0.16	0.74
15-Oct-04	2	3.60	0.66	5.90	0.30	1.96	0.20	0.64
20-Oct-04	1	3.44	0.69	5.78	0.47	1.88	0.33	0.59
20-Oct-04	2	3.57	0.59	5.86	0.35	1.93	0.26	0.77
27-Oct-04	1	3.54	0.66	5.71	0.50	1.95	0.22	0.94
27-Oct-04	2	3.70	0.54	5.87	0.33	1.99	0.11	0.86
03-Nov-04	1	3.63	0.57	5.87	0.35	1.95	0.22	0.85
03-Nov-04	2	3.63	0.53	5.90	0.30	1.99	0.08	0.89
10-Nov-04	1	3.46	0.67	5.80	0.42	1.91	0.29	1.18
10-Nov-04	2	3.56	0.66	5.82	0.41	1.96	0.20	0.65

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Figure 7.2. An example of cricket data that will be made available for analysis in SigmaStat and/or SigmaPlot.

Cave Cricket Monitoring Protocol for Mammoth Cave National Park

Standard Operating Procedure (SOP) # 8

Reporting

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP gives step-by-step instructions for reporting on cave cricket population structure and dynamics data collected at Mammoth Cave National Park. The SOP describes the procedure for formatting a report, the review process and distribution of completed reports. Efficient reporting on monitoring results is critical in assisting park Resource Managers in management decisions. Therefore, a reporting schedule is given with critical dates identified. Timely production of appropriate reports is the responsibility of the project leader and the program coordinator.

I. Report Format

General

Reports should be produced on high quality white paper, 215 x 280 mm in size. Font size of all text should be 12 point unless smaller font aids in fitting information on tables. Times New Roman font should be used throughout text. However, other text fonts are acceptable if used consistently throughout the document. Text is left justified with 3-cm margins on all sides. Words should not be hyphenated on the right side of text.

Page numbers and headers should be placed in the upper-right corner of each page starting with page two of the report. One exception to page numbering and headers is with figures (including pictures and illustrations), if a separate figure title pages is used place number and heading on these pages and leave them off pages containing the figures. Headers should contain an abbreviated version of the report title.

Bolding and underlining should be used minimally in the body of the text unless used on section headings and subheadings. Use italic font for scientific names of species. When using both common and scientific names, list scientific name with first mention of common name only.

Three levels of section headings may be used. First-level headings are all upper-case letters, bolded and left-justified with a sequenced whole number to it left. Second-level headings are bolded and left justified similar to first-level headings with sequenced numbers to the first decimal place. However, only the first letter in each word is capitalized. Third-level headings

are indented five spaces and the first letter in each word is capitalized. Third level heading are not bolded, underlined or numbered. Third-level headings may be italicized followed by a period and two hyphens or bulleted.

Reports should be direct and concise, avoid superfluous wording. Refer to CBE Style Manual (CBE Style Manual Committee 1994) or Writing with Precision, Clarity and Economy (Mack 1986) for aids in writing. Also see Strunk and White (1979) and "Notes on Writing Papers and Theses" (Lertzman 1995) for help in structuring sentences and paragraphs for clarity.

Tables

Tables should be placed within the text of a report or immediately following the literature cited section. Tables should be numbered in sequence regardless of where they are located. Table headers are placed at the top of a table. Horizontal lines are used to separate the table heading from column headings, column headings from the table and to signify the end of the table. Vertical lines should not appear on a table.

Figures

Figures should be placed within the text of a report or immediately following tables behind the literature cited sections. Figures should be numbered in sequence regardless of where they are located. Figure captions are placed below the figure if it is included in the text or on a separate sheet of paper preceding the figure if included after the literature cited section. Both tables and figures should contain information not presented in the body of the text. Also, tables and figures should not duplicate information already presented in the body of the text.

Pictures

Treat as figures.

Report Outline

TITLE PAGE

- Title
- Author(s)
- Institutions
- Prepared for
- Date

TABLE OF CONTENT PAGE (optional)

EXECUTIVE SUMMARY PAGE (abstract)

1.0 INTRODUCTION

1.1 Background

1.2 Justification for Study

1.3 Objectives

2.0 METHODS

2.1 Study area(s)

2.2 Field method(s)

2.3 Analytical method(s)

3.0 RESULTS

4.0 DISCUSSION

5.0 MANAGEMENT IMPLICATIONS

6.0 ACKNOWLEDGEMENTS

7.0 LITERATURE CITED
See Section IV, Literature Cited for format examples.

APPENDIX (optional)

II. Review Procedure

Internal Review

Annual reports on cricket monitoring will be written by the project leader, and/or crew leader(s) under the direction of the project leader. One or more internal reviews for grammatical soundness will be sought prior to submitting the report to MACA Management and Cumberland Piedmont Network (CUPN) Management. Internal review by MACA Prototype or CUPN personnel skilled in technical writing for clarity and directness should fulfill this review requirement. Internal reviews will be conducted by MACA Prototype staff and/or other persons sought out for their language skills.

If reports are written to update findings only and they do not deviate significantly from previously reviewed and distributed reports then the review process may stop here. However, review by park staff and subsequent external reviews must be sought for new reports or those that deviate significantly from previously reviewed and distributed reports. Also, if management activities within a park are not clearly understood, then park review should be sought for a report to clarify results and management implications.

Park Review

Park staff, generally Resource Managers, are in a unique position in that they can supply details about management actives that may influence findings presented in a report. Also, they will be the ones applying management recommendations to their park. Therefore, review by park staff is vital to the interpretation of findings and the assessment of proposed management implications. Review by park staff should be conducted before a report is submitted for external review.

External Review

External review by two or more experts on caves and invertebrate monitoring should be sought for the first report in a series of annual reports. In addition, analytical methods employed on data presented in the report need to be reviewed by one or more statisticians. If a report updates a previously reviewed and distributed report then external review is not required. However, external reviews must be sought for new reports or those that deviate significantly from previously reviewed and distributed reports. In order to conserve reviewer time, external reviews must follow the internal and park review process.

All review comments must be addressed, be it their inclusion in the report or reason for excluding them from the report. The responsibility to edit a report falls to the senior author of the report or their designee.

III. Distribution Procedure

Identifying Stakeholders

The number one stakeholder in our Cave Cricket Monitoring efforts is the Park Service management staff at Mammoth Cave National Park. One additional stakeholder includes the National Park Service's Cumberland Piedmont Network program. Potential stakeholders include any of the national park units with significant cave cricket communities, state and federal wildlife agencies, universities and the general public.

Distributing Report

Annual reports will be provided to resource managers at Mammoth Cave National Park where cave cricket monitoring was accomplished. Additionally, a copy will be kept on file with the Cumberland Piedmont Network office of the National Park Service, Mammoth Cave, Kentucky and made available to all interested parties upon request.

The data management plan for the CUPN-MACA Monitoring program (Moore et al. 2004) describes appropriate procedures to respond to FOIA requests, including the protection of sensitive data such as cave and endangered species locations. Reports containing non-sensitive data will be disseminated through the CUPN-MACA Monitoring program's website. Through the website, those requesting information will be asked to provide information to document by whom and for what purpose the report is being used. By documenting requests, users can be informed when updated reports are available. Users requesting paper copies will be documented also.

In an effort to disseminate findings in a timely manner, annual reports should be completed by March 31 of the year following data collection. More extensive summary reports should be completed every five to ten years depending on how fast habitat conditions are

changing and how critical summary information is to setting management goals influencing cave cricket populations within a park. Summary reports may be used in place of annual reports for the year in which the last data is collected.

IV. Literature Cited

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Cave Cricket Monitoring Protocol for Mammoth Cave National Park

Standard Operating Procedure (SOP) # 9

Revising the Protocol

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure explains how to make changes to the Cave Cricket monitoring Protocol Narrative for Mammoth Cave National Park (MACA) and accompanying SOPs, and how to track these changes. Any changes in the Cave Cricket monitoring protocol will adhere to the guidelines contained in this SOP. Observers asked to edit the Protocol Narrative or any one of the SOPs need to follow this outlined procedure in order to eliminate confusion in how data is collected and analyzed. All observers should be familiar with this SOP in order to identify and use the most current methodologies, and should see the revision history log attached to each SOP.

Procedures:

1. The Cave Cricket Monitoring Protocol Narrative for Mammoth Cave National Park and accompanying SOPs has attempted to incorporate the most sound methodologies for collecting and analyzing data. However, all protocols regardless of how sound, require editing as new and different information becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken.
2. All edits require review for clarity and technical soundness. Oversight of the revision process for all protocols is the responsibility of the MACA Prototype coordinator. When a potential modification to a protocol is identified, the project leader consults with the prototype coordinator, who then decides whether the change should be considered “small” or “significant”. Small changes or additions to existing methods will be reviewed in-house by MACA Prototype staff designated by the prototype coordinator. However, if a substantial change, such as a change in methods is sought, then an outside review may be required. The need will be determined by the protocol coordinator and project leader. Reviewers will be selected based on the type of change (i.e., changes in sampling sites versus changes in sampling design or sampling analysis). Regional and National staff of the National Park Service, as well as the U.S. Geological Survey-Biological Resource Discipline, with familiarity in ecological research and data analysis will be utilized as reviewers. Also, experts in cave

invertebrate monitoring, research, and statistical methodologies outside of the National Park Service will be utilized in the review process, as needed.

3. Edits and protocol versioning must be documented in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP being edited only. Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, …etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 …etc). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
4. Depending upon the magnitude and nature of a proposed change, it could have significant implications for data management. The database may have to be edited by the data manager to accompany changes in the Protocol Narrative and SOPs. The database may have to be edited by the data manager to accompany changes in the Protocol Narrative and SOPs. Thus the data manager must be consulted prior to implementing changes to protocols. Immediately after the changes to the Protocol Narrative or SOP(s) have been made, inform the data manager, so the new version number can be incorporated in the metadata of the project database.
5. Post new versions on the Internet and in the "Narratives" or "SOP" subfolder for the project. Forward copies to all individuals with a previous version of the effected Protocol Narrative or SOP. Archive a copy of each previous version in the MACA curatorial facility.